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Report of the PSARC Groundfish Subcommittee Meeting, November 13 – 16, 2001

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PACIFIC SCIENTIFIC ADVICE REVIEW COMMITTEE

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GROUNDFISH

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SUMMARY

The PSARC Groundfish Subcommittee met on three occasions in 2001. A planning meeting was held May 23, 2001 to identify stock assessments required for 2001. A technical meeting was held September 12-13, 2001 to review data and methods used in the 2001 assessments. The final meeting was held November 13-16, 2001 to review the assessments and provide scientific advice. External participants from Canadian Sablefish Association, the Sierra Club of BC, Pacific Halibut Management Association (PHMA) and Canadian Groundfish Resource Conservation Society (CGRCS) attended the meeting.

General Subcommittee Discussion and Concerns

Improved catch statistics

The Subcommittee is concerned about the continuing problem of catch statistics. The Subcommittee noted that estimates of catch by species are a required component for all stock assessments.

Ecosystem considerations

With the recent thrust to understand and manage species in an ecosystem context, the Subcommittee recommended that a working group be considered to integrate efforts to understand trophic level dynamics, initially for the Strait of Georgia. The multi-disciplinary group should focus on the dynamics of lingcod and inshore rockfishes in relation to the productivity in the Strait of Georgia, and interactions with other species (particularly marine mammals).

G2001-01: Sablefish stock assessment for 2001 and advice to managers for 2002.

The Subcommittee accepted the conclusion that the sablefish population has been low and relatively stable since 1996. The Subcommittee accepted the recommendation in the paper that the current 4000 t TAC can be maintained for another year.

G2001-02: Assessments of lingcod in the Strait of Georgia.

The Subcommittee recognized that Georgia Strait lingcod have experienced a precipitous decline in abundance since the 1950's and early 1960's and have been at critically low levels throughout the 1990's.

The Subcommittee recommended that fishing mortality should be reduced to as close to zero as possible.

The Subcommittee recommended development of survey methods to provide information on the abundance and distribution of lingcod in the Strait of Georgia.

The Subcommittee recommended that ecosystem research be considered to address current limitations of single-species assessments.

G2001-03: Preliminary status report on bocaccio (*Sebastes paucispinis*) in BC waters.

The Subcommittee was concerned that the decline of abundance indices for Bocaccio derived from the west coast Vancouver Island shrimp survey data and, in particular, the U.S. triennial survey data indicate a serious decline.

The Subcommittee concurred with the authors that the stock status in the Strait of Georgia, off the west coast of Vancouver Island and in Queen Charlotte Sound could not be inferred from surveys off the lower west coast of Vancouver Island, The Subcommittee requested the revised version of the Working Paper present a detailed review of all survey indices to assess trends in bocaccio abundance in other areas.

G2001-04: Inshore rockfish stock assessments for the West Coast of Canada in 2001 and recommendations for management in 2002.

The Subcommittee agreed that there is a serious conservation concern for inshore rockfish. The Subcommittee noted that current quota-based management does not provide sufficient protection against detrimental fishing effects and may fail to meet conservation objectives.

The Subcommittee recommended that research efforts for inshore rockfish species be directed to evaluating the design and potential of harvest refugia as an adjunct to quota management.

The Subcommittee recommended improvement of catch data for all inshore rockfish in all fisheries.

The Subcommittee recommended the initiation of stock monitoring programs and development of population indices in conjunction with harvest management initiatives.

G2001-05: A Phase '0' review of elasmobranch biology, fisheries, assessment and management.

The Subcommittee accepted the conclusions of the Working Paper that recent increased catches of skates in BC to an average of about 1500 t in 1996 to 2000 from a historical average of 382 t, is a significant change.

The skate fishery has reached a level where managers should consider caps for all species in all areas, taking account of the Individual Vessel Quota (IVQ) context and related fishery impacts.

G2001-06: Assessment of Pacific cod off the West Coast of Vancouver Island and Hecate Strait, November, 2001.

The Subcommittee accepted the conclusions that both the West Coast Vancouver Island (WCVI) and the Hecate Strait stocks are at historic lows.

The Subcommittee accepted the yield options (Tables 1 and 2) presented in the paper for the WCVI and Hecate Strait stocks.

G2001-07: Information on non-target species in the International Pacific Halibut Commission standardized stock assessment survey.

The Subcommittee agreed with the author's conclusion that the Standardized Stock Assessment (SSA) survey cannot be used as an index of inshore rockfish abundance and that a dedicated survey for rockfish may be a better alternative.

The Subcommittee agreed with the authors that the SSA survey might be a viable means for indexing spiny dogfish and sablefish depending on the objectives.

The Subcommittee recommended that individual investigators assess the utility of the SSA surveys based on the their research objectives.

G2001-08: Assessment of the Canadian longspine thornyhead (*Sebastolobus altivelis)* for 2001.

The Subcommittee was concerned about the 25% decline in CPUE for the assessed region off the Southern West Coast of Vancouver Island (SWVI).

The Subcommittee expressed concern that this fishery has developed rapidly in a short period but also noted that measures have been taken which have reduced the catch in this area.

The Subcommittee expressed concern that the protocol for gathering data, uncertainties in these data, and the current management scheme may not provide timely enough feedback given the apparent rate of decline in CPUE. Therefore, the Subcommittee supported development of a plan to use experimental design in the conduct of the fishery to increase the rate at which this information can be obtained.

The Subcommittee stated that a continued decline in catch rates in the SWVI fishery may require a reduction in quota prior to implementation of an experimental fishing plan. However, the Subcommittee supported current quotas for the 2002/2003 fishing year of 425 t in both the traditional and exploratory fisheries.

G2001-09: An update for the British Columbia experimental fishery for Pacific hagfish (*Eptatretus stoutii)*

The Subcommittee agreed that data are limited and that there is insufficient information to support the authors' statement that the present level of exploitation is of low impact.

The Subcommittee recommended to continue to limit the experimental fishery to Areas 23 and 123 until sufficient information is obtained to assess the impacts of the current levels of fishing

G2001-10: Turbot stock assessment for 2001 and recommendations for management in 2002.

The Subcommittee accepted the conclusion that removals of arrowtooth flounder off the west coast of Canada are at or below sustainable levels. Therefore, the Subcommittee recommended that catch limits based on the average annual catches over the last four years be considered.

G2001-11: Pacific Ocean perch assessment for the West Coast of Canada in 2001.

The Subcommittee accepted the Working Paper conclusion that the available evidence does not justify an increase in the POP quota.

The Goose Island Gully stock is currently experiencing a period of low recruitment, which suggests caution in assigning harvest.

The Subcommittee supported the Working Paper recommendations for fishery independent surveys, synoptic sampling of fisheries, and data integrity projects.

The lack of these data were identified by the Subcommittee as the major impediment to improvement of the stock assessment.

SOMMAIRE

Le Sous-comité du CEESP sur le poisson de fond s'est réuni à trois reprises en 2001. Une réunion de planification a eu lieu le 23 mai 2001 pour déterminer les évaluations des stocks à réaliser en 2001. Une réunion technique s'est tenue les 12 et 13 septembre 2001 pour examiner les données et les méthodes utilisées dans les évaluations de 2001. La dernière réunion s'est tenue du 13 au 16 novembre 2001 pour examiner les évaluations et fournir des conseils scientifiques. Des représentants de la Canadian Sablefish Association, du Sierra Club de la C.-B., de la Pacific Halibut Management Association (PHMA) et de la Canadian Groundfish Resource Conservation Society (CGRCS) ont assisté à la réunion à titre de participants externes.

Observations et préoccupations générales du Sous-comité

Amélioration des statistiques des prises

Le Sous-comité s'inquiète du problème constant des statistiques des prises. Il remarque que les estimations des prises par espèces constituent une composante essentielle de toutes les évaluations des stocks.

Considérations écosystémiques

Vu la tendance récente à comprendre et à gérer les espèces dans un contexte écosystémique, le Sous-comité recommande d'envisager la mise sur pied d'un groupe de travail qui intégrerait les travaux visant à comprendre la dynamique des niveaux trophiques, d'abord pour le détroit de Géorgie. Ce groupe pluridisciplinaire devrait se concentrer sur la dynamique de la morue-lingue et des sébastes côtiers en relation avec la productivité du détroit de Géorgie ainsi que sur leurs interactions avec d'autres espèces (en particulier les mammifères marins).

G2001-01 : Évaluation des stocks de morue charbonnière en 2001 et conseils à l'intention des gestionnaires pour 2002

Le Sous-comité accepte la conclusion selon laquelle la population de morue charbonnière est petite et relativement stable depuis 1996. Le Sous-comité accepte la recommandation présentée dans le document voulant que le TAC actuel de 4000 t soit maintenu pour une autre année.

G2001-02 : Évaluation des stocks de morue-lingue dans le détroit de Géorgie

Le Sous-comité reconnaît que l'abondance de la morue-lingue du détroit de Géorgie a chuté depuis les années 1950 et le début des années 1960 et qu'elle était à des niveaux dangereusement bas tout au long des années 1990.

Le Sous-comité recommande de réduire la mortalité par pêche le plus possible.

Le Sous-comité recommande de mettre au point des méthodes de relevé qui renseigneront sur l'abondance et la répartition de la morue-lingue dans le détroit de Géorgie.

Le Sous-comité recommande que l'on envisage d'effectuer de la recherche écosystémique pour combler les lacunes actuelles des évaluations portant sur une seule espèce.

G2001-03 : Rapport préliminaire sur l'état des stocks de bocaccio (*Sebastes paucispinis*) dans les eaux de la C.-B.

Le Sous-comité s'inquiète du fait que la baisse des indices d'abondance du bocaccio (calculés à partir des données du relevé de la crevette de la côte ouest de l'île de Vancouver et surtout des données du relevé triennal américain) indique un grave déclin des stocks.

Le Sous-comité convient avec les auteurs que les relevés effectués au large de la côte ouest méridionale de l'île de Vancouver ne permettent pas de déduire l'état des stocks du détroit de Géorgie, de la côte ouest de l'île de Vancouver et du détroit de la Reine-Charlotte. Le Sous-comité demande que la version révisée du document de travail examine en détail tous les indices de relevés pour évaluer les tendances des effectifs de bocaccios dans d'autres secteurs.

G2001-04 : Évaluations des stocks de sébastes côtiers de la côte Ouest du Canada en 2001 et rcommandations pour leur gestion en 2002

Le Sous-comité convient que la conservation des sébastes côtiers est très préoccupante. Le Sous-comité remarque que la gestion par quotas actuelle ne prévient pas suffisamment les effets néfastes de la pêche et qu'elle ne permet peut-être pas d'atteindre les objectifs de conservation.

Le Sous-comité recommande que des travaux de recherche concernant les espèces de sébastes côtiers soient effectués pour évaluer la conception et le potentiel de sanctuaires de pêche comme complément à la gestion par quotas.

Le Sous-comité recommande d'améliorer les données sur toutes les prises des diverses espèces de sébastes côtiers.

Le Sous-comité recommande de lancer des programmes de surveillance des stocks et d'élaborer des indices de population, en plus des mesures de gestion de la pêche.

G2001-05 : Examen d'étape 0 de la biologie, des pêches, de l'évaluation et de la gestion des élasmobranches

Le Sous-comité accepte la conclusion du document de travail selon laquelle la hausse récentes des prises de raies en C.-B. (moyenne d'environ 1500 t de 1996 à 2000, par rapport à une moyenne historique de 382 t) constitue un changement important.

La pêche de la raie a atteint un niveau tel que les gestionnaires devraient envisager d'établir des plafonds de prises pour toutes les espèces et dans tous les secteurs en tenant compte du régime de quotas individuels de bateaux (QIB) et des effets connexes de la pêche.

G2001-06 : Évaluation des stocks de morue du Pacifique de la côte ouest de l'île de Vancouver (WCVI) et dans le détroit d'Hécate, novembre 2001

Le Sous-comité accepte la conclusion selon laquelle les stocks de la côte ouest de l'île de Vancouver (WCVI) et du détroit d'Hécate sont à leurs niveaux les plus bas jamais enregistrés.

Le Sous-comité accepte les options de production (tableaux 1 et 2) présentées dans le document pour les stocks de WCVI et du détroit d'Hécate.

G2001-07 : Information sur les espèces non visées obtenue lors du relevé d'évaluation normalisée des stocks de la Commission internationale du flétan du Pacifique

Le Sous-comité convient avec les auteurs que le relevé d'évaluation normalisée des stocks ne peut pas fournir d'indice de l'abondance du sébaste côtier et qu'il pourrait être préférable de réaliser des relevés visant expressément le sébaste.

Le Sous-comité convient avec les auteurs que, selon les objectifs, le relevé d'évaluation normalisée des stocks pourrait être un moyen viable de calculer des indices d'abondance de l'aiguillat commun et de la morue charbonnière.

Le Sous-comité recommande que les chercheurs individuels évaluent l'utilité des relevés d'évaluation normalisée des stocks en fonction de leurs objectifs de recherche.

G2001-08 : Évaluation des stocks canadiens de sébastolobe à longues épines (*Sebastolobus altivelis*) en 2001

Le Sous-comité s'inquiète de la baisse de 25 % des CPUE dans le secteur à l'étude situé au large de la côte ouest méridionale de l'île de Vancouver (SWVI).

Le Sous-comité s'inquiète du développement rapide de cette pêche sur une courte période, mais il remarque que les mesures qui ont été prises ont permis de réduire les captures dans ce secteur.

Le Sous-comité s'inquiète du fait que le protocole de cueillette de données, l'incertitude de ces données et le plan de gestion actuel ne fournissent peut-être pas une rétroaction suffisamment rapide compte tenu du taux de déclin apparent des CPUE. Le Sous-comité appuie donc l'élaboration d'un plan visant à structurer la pêche selon un plan expérimental afin d'accélérer l'acquisition des données.

Le Sous-comité affirme que, si les taux de capture de cette pêche dans la zone SWVI continuent de baisser, il pourrait être nécessaire de réduire les quotas avant la mise en œuvre d'un plan de pêche expérimental. Toutefois, le Sous-comité appuie le maintien des quotas actuels de 425 t pour l'année 2002-2003, tant pour la pêche traditionnelle que la pêche exploratoire.

G2001-09 : Le point sur la pêche expérimentale de la myxine brune (*Eptatretus stoutii*) en Colombie-Britannique

Le Sous-comité convient que les données sont limitées et qu'elles sont insuffisantes pour appuyer l'affirmation des auteurs selon laquelle l'impact du niveau d'exploitation actuel serait faible.

Le Sous-comité recommande de continuer de restreindre la pêche expérimentale aux zones 23 et 123 jusqu'à ce que l'on recueille suffisamment de données pour évaluer les impacts des niveaux de pêche actuels.

G2001-10 : Évaluation des stocks de plie à grande bouche en 2001 et recommandations pour sa gestion en 2001

Comme le Sous-comité accepte la conclusion voulant que les prises de plies à grande bouche le long de la côte Ouest du Canada ne dépassent pas les seuils de durabilité, il recommande d'envisager l'établissement de limites de captures fondées sur la moyenne des prises annuelles depuis quatre ans.

G2001-11 : Évaluation des stocks de sébaste à longue mâchoire de la côte Ouest du Canada en 2001

Le Sous-comité accepte la conclusion du document de travail selon laquelle les données disponibles ne justifient pas une augmentation du quota de sébastes à longue mâchoire.

Comme le recrutement au sein du stock de Goose Island Gulley est actuellement bas, il faudrait gérer cette pêche avec prudence.

Le Sous-comité appuie les recommandations du document de travail en ce qui concerne des relevés indépendants des pêches, l'échantillonnage synoptique des pêches et des projets sur l'intégrité des données.

Selon le Sous-comité, l'insuffisance de ces données constitue le principal obstacle à l'amélioration de l'évaluation des stocks.

INTRODUCTION

The PSARC Groundfish Subcommittee met on three occasions in 2001. A planning meeting was held May 23, 2001 to identify stock assessments required for 2001. A technical meeting was held September 12 - 13, 2001 to review data and methods used in the 2001 assessments. The final meeting was held November 13 - 16, 2001 to review the assessments and provide scientific advice. External participants from Canadian Sablefish Association, the Sierra Club of BC, the Pacific Halibut Management Association (PHMA) and the Canadian Groundfish Resource Conservation Society (CGRCS) attended the meeting.

The Subcommittee Chair opened the meeting welcoming the participants. During the introductory remarks the objectives of the meeting were reviewed, and the Subcommittee accepted the meeting agenda (Appendix 1).

The Subcommittee reviewed eleven Working Papers. Working Paper titles and authors are listed in Appendix 2. A list of meeting participants, observers and reviewers is included as Appendix 3.

GENERAL SUBCOMMITTEE DISCUSSION AND CONCERNS

Improved catch statistics

The Subcommittee is concerned about the continuing problem of catch statistics. Specific improvements include: 1) obtaining catch data from commercial hook and line, recreational and First Nation fisheries by species; 2) recreational monitoring consider designs appropriate for all species; and 3) expanding the recreational monitoring programs to encompass catch coastwide. The Subcommittee noted that estimates of catch by species are a required component for all stock assessments, but are not sufficient alone to produce reliable assessments.

Ecosystem considerations

The Subcommittee considered the assessment and conservation of inshore resources, specifically rockfishes and lingcod. They referred to previous PSARC Subcommittee reports (1996) where it was pointed out that alternative approaches were needed. With the recent thrust to understand and manage species in an ecosystem context, the Subcommittee recommended that a working group be considered to integrate efforts to understand trophic level dynamics, initially for the Strait of Georgia. Such a group would have to be composed of experts from various scientific fields. The group should focus on the dynamics of lingcod and inshore rockfishes in relation to the productivity in the Strait of Georgia, and interactions with

other species (particularly marine mammals). This would place the Department in a better position to develop and assess alternative management actions.

WORKING PAPER SUMMARIES, REVIEWS AND DISCUSSION

G2001-01: Sablefish stock assessment for 2001 and advice to managers for 2002.

V. Haist, R. Hilborn, M. Wyeth **Accepted subject to revisions**

Summary

The 2001 sablefish stock assessment addresses the objectives and questions specified by the DFO Groundfish Management Unit in their *Request for Working Paper*. The PSARC document includes summaries of the sablefish fishery and biological information, and provides analyses related to the fishery and tag dynamics.

As in previous sablefish assessments, the primary information we use to assess the stock is tagging data. The tagging analysis conducted for the current assessment uses only tag recoveries in the year following release to estimate exploitation rates and stock abundance. This analysis does not incorporate stock dynamics so we do not conduct stock projections.

BC sablefish stock abundance declined through the early 1990's, and has been relatively stable since 1996. The estimated abundance trends from tagging analysis, commercial CPUE indices, and survey CPUE indices are consistent. We believe the sablefish stock abundance is currently low and stable.

Estimated exploitation rates, in the range of 10-13% in recent years, are at the high end of the range we recommend for the sablefish stock. However, we believe that our estimates are biased high due to the disproportionate release of tagged fish in areas and depth zones of major commercial fishing effort, rather than randomly through the population. Sablefish survey data, including addition sets conducted during the 2000 survey in the 600-800 fm depth range, indicate fairly high fish density at depths greater than 450 fm where only a small fraction of tag releases and fishery effort occurs.

We estimate that approximately 30% of sablefish tagged off the Queen Charlotte Islands move to Alaskan waters. However, on the basis of analyses conducted to date, we are not in a position to provide specific advice regarding management of northern BC sablefish.

Reviewers' Comments

Reviewer #1

The reviewer concluded that the assessment approach was reasonable and the document generally well written. The assessment supports the major conclusions that: 1) sablefish abundance declined through the early 1990's; 2) abundance currently is low and stable; and 3) a 2002 TAC of 4,000 t is appropriate. The reviewer was concerned that comparing length frequencies over time, by gear, mixes gear and time effects. The reviewer also noted that using the average of the exploitation rate ratios for years where there are no estimates of BC exploitation rates or reporting rates may bias reporting rates during the 1980s and percentage movement to Alaska. The reviewer asked whether targeting differences between longline and trap gear explained the reported differences in depths fished. The statement that "the harvest rate simulation analysis suggests that harvest rates in the range of 6 to 14% of the vulnerable biomass provide a reasonable trade-off between maximizing catch and maintaining female spawning biomass" implies that the authors believe these scenarios are equally plausible. If this is not true, then an analysis that incorporates different M and stock-recruitment steepness probabilities should be considered. The reviewer echoed the concern by the authors that exploitation rates potentially are biased due to non-random release of tagged fish, and recommended that future tag releases should be random with respect to the vulnerable population. The pattern of steeply decreasing recoveries 3 to 5 years after tag release, followed by small numbers of returns 20 and more years post-release indicate that fish often move to a region with lower exploitation and/or reporting rates. The tag release-recovery simulation supports this hypothesis. Alaska and/or deep water are two possible regions with lower exploitation rates.

Reviewer #2

Reviewer #2 focussed on potential bias in estimates of exploitation rates and biomass due to invalid assumptions in the analysis of tagging data. The reviewer suggested a sensitivity analysis to identify effects of the bias. The reviewer noted that the authors have not adjusted for mortality between the time of tagging and the fishery. The reviewer stated the assumptions required by Petersen-type estimators used in the assessment. Namely, that either all fish in the population had the same chance of being tagged, or all fish in the population had the same chance of being caught in the fishery, or there is complete mixing of tagged and untagged fish. Failure to meet the assumptions could lead to bias, usually that the population was over-estimated leading to an underestimate of the exploitation rate. The reviewer indicated that there may be different catchabilities among size classes because of the escape ring and asked for the potential influences upon the biomass estimate. The reviewer noted that some of the fishery is observed to take place close to tagging sites which may preclude mixing. The Working paper presented data that showed there is very different catchability by age and sex. The reviewer suggested that the effects of the age and sex dependency could be integrated into the

sensitivity analysis. The reviewer pointed out that bias occurs if tagged fish are not available for capture. If only half of the tags are available for capture then the estimates could be out by a factor of 2. The reviewer wondered if there is any evidence that tagging alters the behaviour of the fish. This may be relevant if the fishery takes place soon after tagging when the fish may exhibit trap shyness. The reviewer was not sure what stock components were included in the biomass estimate. The reviewer noted the Alaskan exploitation rates were about 60% of the BC rates, yet both stocks were judged to be low and stable in abundance. He asked what biological or ecological characteristics could lead to similar populations in apparently the same steady state at such different exploitation rates.

Subcommittee Discussion

The Subcommittee accepted the conclusion that the sablefish population has been low and relatively stable since 1996. The Subcommittee accepted the recommendation in the paper that the current TAC can be maintained for the 2002/2003 fishing year.

The conclusion of a stable biomass is dependent on the assumption that the tag reporting rates have been stable since 1997. The authors stated that estimates of reporting rates were based on a between-vessel tag return rate analysis which is likely to underestimate the actual return rate. Since 1997, tag return rates are likely in the range of 0.9 to1.0. The authors suggested that these estimates will be updated in next year's assessment. It was mentioned by industry that in 2001 observed trips could be compared with unobserved trips to estimate the reporting rate.

General discussion on appropriate harvest levels ensued. The Subcommittee asked what signal in the abundance indices would trigger an adjustment in the harvest levels. The authors stated that the stock levels appeared to be low and stable since 1996, and that this condition was the justification for recommending similar harvest levels. The authors stated that any reduction in stock abundance would warrant a decrease in the TAC from current levels.

The Subcommittee questioned whether the estimated decline in BC biomass was greater than that estimated in Alaska. The authors commented that the first two (extremely high) points for the BC survey CPUE index were biased high and if these points were corrected for the bias, then the estimated levels of decline would be similar to Alaska. In addition, there is exchange of fish between these two areas.

The paper suggested that additional work is required to develop a recruitment index based on juvenile survey data. The Subcommittee asked whether this additional work required new field work or further analysis of existing information. The response indicated that the existing data required analysis before a recommendation on future field work was put forward.

General discussion on deep water refugia for sablefish ensued. The authors noted that habitat at depths greater than that usually fished by the sablefish fleet yielded high catch rates. The Subcommittee queried whether the deep waters served as harvest refugia. In response, the authors stated that this was more likely to be true in the south than in the north simply due to the observed movement of tagged fish. Sablefish tend to move deeper in the south but tend to move in a northerly direction in the north. The shelf is much steeper in the North and there is less habitat area compared to the southern coast. The deep water area in the South has been surveyed for thornyheads and this may be useful for describing the distribution and abundance of sablefish.

The authors were asked by the Subcommittee to comment on the stability of the Alaskan exploitation rate estimates compared to those from BC. The authors indicated that the Alaskan estimates were more stable because they are mediated by a population dynamics model and a long time series of fishery independent data. The authors explained that the BC exploitation rate estimates were higher than equivalent estimates from Alaska primarily due to the biases in these estimates discussed in the paper.

The author agreed with Reviewer #1's conclusion that comparing length frequencies over time, by gear, mixes gear and time effects, but stated that there were no longline samples for comparison, although this could be addressed by revising the biosampling.

In response to the potential bias in the tagging analysis identified by Reviewer #2, the Subcommittee accepted the sensitivity analysis of the biomass estimate to bias/uncertainty presented by the authors at the meeting and encouraged the authors to include the results in revisions to the Working Paper. Reviewer #2 expressed a concern that most of the assumption violations in the Peterson estimator tend to inflate the estimated population size and hence the current estimated exploitation rates are biased low. The authors disagreed, suggesting their analysis indicated the magnitude of negative biases due to incomplete mixing/differential fishing mortality rates and under-estimation of reporting rates are probably greater than the positive bias due to migration, recruitment and natural mortality. The authors also stated that the biomass estimates are only used as a relative estimate to evaluate overall trends in abundance.

The Subcommittee acknowledged the authors' conclusion that future management advice of species should be based on decision rules, and agreed that measurable stock indicators should be presented. The Working Paper noted the "objectives based fisheries management" exercise may address this requirement.

Subcommittee Recommendations

The Subcommittee accepted the recommendation in the paper that the current 4000 t TAC can be maintained for another year.

G2001-02: Assessments of lingcod in the Strait of Georgia.

J.R. King ** Accepted subject to revisions**

Summary

This Working Paper examines recreational fishing information, nest density survey results and biological data for lingcod within the Strait of Georgia. Annual catch estimates (pieces) from the Strait of Georgia creel survey program are updated from 1999. Biological data on the length (cm) of lingcod retained by recreational fishers is updated from 1994. Mean lengths and a weight-length relationship is used to convert estimated catch in pieces to estimated catch in tonnes. Recreational catch per unit effort (CPUE) indices are presented as a relative measure of lingcod abundance trends. In 2001, a nest density SCUBA survey was conducted on Snake Island in Minor Statistical Area 17 and the results are compared to 1990, 1991 and 1994 results. Biological data on nest guarding males and egg mass volume were collected during 1990 and 2001. The Vancouver Aquarium Marine Science Centre conducts an annual egg mass count survey in Howe Sound (Minor Statistical Area 28) and their analyses and results are provided for 1994-2001.

The recreational CPUE index has remained fairly constant from 1982-2000. There have been slight decreases and increases (e.g., decrease 1985-1995) however these are non-significant. Since 1990, there is evidence of two above average year-classes (1995 and 1999 or 2000) and following these, increases in the abundance of juvenile lingcod, however there is a lack of evidence for an increase in the abundance of large, adult lingcod. It is important to note that in some areas the size of landed lingcod in the recreational fishery is below the 65 cm size limit. An education campaign is recommended as means of reducing the retention of under-sized lingcod by sports fishers. There is some slight indication that the spawning population has increased, but the evidence is not overwhelming. The size of nest guarding males was not significantly larger in 2001 than in 1990.

Since the closure of the commercial fishery in 1990, lingcod abundance appears to have remained at very low and stable levels. Presently, there is no indication that overall lingcod population abundance has continued to decline nor rebuilt to levels similar to pre-collapse of the commercial fishery. In order to foster an increase in lingcod abundance, commercial fishing should remain closed and recreational closures should be implemented.

Reviewers' Comments

Reviewer #1

Reviewer #1 agreed with the author's conclusion that adult lingcod abundance in the Strait of Georgia is at low levels despite above average year classes in 1995 and

1999/2000. The reviewer suggested that experiences in Puget Sound might help establish methods for stock monitoring, management and assessment of Lingcod in the Strait of Georgia. The reviewer was concerned that the CPUE index identified in the Working Paper does not account for the changes in kept and released fish. Given that there are size data collected in the Creel Survey, perhaps a size based CPUE index could be developed to assess changes in recruitment and the abundance of larger fish. The reviewer noted that a CPUE index derived from Creel Survey data is problematic because of the focus on salmon rather than groundfish. The reviewer felt that new fishery independent methods to assess abundance of larger older lingcod should be considered. The reviewer was concerned that results of the two lingcod nest surveys are not consistent and likely not representative of the entire Strait of Georgia. The reviewer concurred with the author that the targets for stock rebuilding should be developed in consultation with managers and stakeholders.

Reviewer #2

The reviewer thought that the Working Paper was well organized and convincing in its analysis based on DFO databases. The reviewer identified a number of sources of traditional knowledge related to Strait of Georgia lingcod that were not covered in the Working Paper. Specific examples presented in the review include anecdotal evidence for differential lingcod survival patterns affected by distributional changes of herring prey in some Minor Areas. The reviewer suggested area closures in Areas 15, 28 and 18 to allow for an assessment of relative impact of recreational fishing on lingcod biomass recovery, compared to climate impacts. Reviewer #2 stated that if such limited restrictions were not showing effects within several years, then adaptive management might lead to additional Area closures. The reviewer was concerned that the precautionary approach would seem to mitigate in favour of a closure on jigging for all groundfish to forestall serial depletion of other species if a lingcod-only closure occurred.

Subcommittee Discussion

The Subcommittee recognized that Georgia Strait lingcod have experienced a precipitous decline in abundance since the 1950's and early 1960's and have been at critically low levels throughout the 1990's. The long-term decline is reflected in the trend in commercial landings (Fig. 1). Subcommittee discussion focussed on current abundance indicators and recommendations to address the current status of the population.

Since the prohibition of lingcod retention by commercial fisheries in the Strait of Georgia in 1990, data sources to estimate abundance have been confined to CPUE indices from the recreational fishery and dive surveys of nest densities at Snake Island and in Howe Sound.

For the recreational CPUE indices, the Subcommittee accepted the author's recommendation to use effort based on fishing hours (CPUE index I3) rather than effort based on the number of interviews (CPUE indices I1 and I2) because index I3 incorporated an appropriate measure of effort. Index I3 has shown no change in abundance since 1982.

Nest density estimates at Snake Island and nest counts in Howe Sound showed weak temporal trends and did not indicate significant changes in stock abundance, although concerns were expressed by the author about the effects of differences and/or changes in the surveys over the years.

Explanations for both the population decline from high levels 40-50 years ago and a lack of recovery despite the closure of the commercial fishery, include continued over-fishing, poor recruitment, the lack of knowledge about productivity changes, marine mammal predation and mortality from pollution sources. The impacts of these factors were discussed but are not known. The Subcommittee discussed the potential for interaction between marine mammal predators and lingcod, and agreed that integrated multi-species approaches to assessment of groundfish in the Strait of Georgia is warranted.

The Subcommittee recognized that the stock is at a very low level, and that there is no indication that stock abundance will remain stable or increase at current harvest levels. The population may not be able to remain stable or increase under current recreational catches (annual catch estimates of retained fish averaged 7,200 fish/yr since 1995). The author pointed out that recreational fishery catch and release mortality estimates from Puget Sound studies were low (<10%), indicating that a non-retention regulation would achieve a reduced fishing mortality. The Subcommittee acknowledged that a complete recreational fishing closure to lingcod, as proposed by the author, or a closure to all species of groundfish, as proposed by reviewer #2 are alternative management measures to reduce catches to near zero. The Subcommittee noted that an education campaign was also recommended by the author as means of reducing the retention of under-sized lingcod in the absence of management measures to eliminate the catch.

Subcommittee Recommendations

1. Fishing mortality on Strait of Georgia lingcod should be reduced to as close to zero as possible.

2. The absence of commercial catch data since 1990 and limitations of the recreational creel data imply that fishery-independent sources of biological and abundance data are required for stock assessment. Thus, the Subcommittee recommended development of survey methods to provide information on the abundance and distribution of lingcod in the Strait of Georgia.

3. Marine mammal predation on lingcod in one of several hypotheses explaining the continued suppression of lingcod abundance in the Strait of Georgia. The Subcommittee recommended that ecosystem research be considered to address current limitations of single-species assessments.

G2001-03: Preliminary status report on bocaccio (*Sebastes paucispinis*) in BC waters.

R.D. Stanley, K. Rutherford, N. Olsen ** Accepted subject to revisions**

Summary

Bocaccio is found in coastal waters of the eastern Pacific Ocean from Alaska to Baja California, Mexico. It is one of 35 species of rockfish found on the Pacific coast of British Columbia. Most catches in BC come from the outer Pacific coast near the edge of the continental shelf. They have been reported in recent years from the Strait of Georgia, Barkley Sound, Queen Charlotte Sound, and Fitz Hugh Sound. Adult bocaccio are found over a variety of bottom types and are typically associated with bottom depths of 60-200 m. They are a bycatch in the trawl and hook-and-line fisheries and a very minor component of the recreational fishery.

Most of the research on bocaccio has been conducted in California owing to its importance in the recreational fishery. They are livebearers; the young are released in the winter. Settlement to the littoral and demersal habitat extends from late spring through the summer. They are thought to mature at 4-5 years of age. Maximum age is unknown but radiometric dating of the ear-bones has indicated a maximum of 40 years. Estimates of instantaneous natural mortality rate (M) for adults have ranged from 0.15-0.25. Maximum reported size is 6.8 kg and 91 cm. Bocaccio have closed swim bladders, thus most die after release unless caught at the surface. While sold commercially, they have a market reputation for "worminess " derived from the presence of a copepod parasite in the fillets.

The abundance of bocaccio in BC waters is unknown. Its low importance has discouraged research, and the low catches in the fisheries limit the utility of fishery-dependent data for tracking abundance. Catches do indicate that bocaccio are present in all coastal waters at the edge of the continental shelf and in at least some inlets and straits. The abundance trend is unknown for the outer north coast. It appears stable for the central coast. Abundance has possibly declined off the southwest coast of Vancouver Island over the last two decades but it appears stable over the last five years. Current commercial catches are low; sport and First Nations catches are probably negligible. The U.S. fisheries of Washington State may have had an impact on the BC population in the past, but these landings are now negligible. There is no evidence that the coastwide population is threatened.

Reviewers' Comments

Reviewer #1

Reviewer #1 commended the authors for consolidating a wide variety of data in a single comprehensive and very comprehensible report. He agreed that the Working Paper provides a good template for future assessments of "minor" (unmanaged) species. His comments mostly related to the interpretation of trends and the nature of the authors' advice to COSEWIC, given that this paper will become the status report solicited by COSEWIC. He emphasized that interpretations about sustainability must be couched in a longer-term perspective and that the 3-generation window appropriate for assessing extinction risk in bocaccio using IUCN (or COSEWIC) criteria is about 30 years. He also suggested that abundance trends should be examined on a logarithmic scale to better evaluate evidence for declining survival associated with a threatening process like overharvest or climate change. From this perspective, both fishery-independent indicators of abundance for the west coast of Vancouver Island (the triennial and shrimp surveys) show rates of decline since 1980 that are biologically highly significant (-97.7% and –87% over 3-generations). However, these trends are inconsistent with trends from commercial catch statistics that the authors' warn are less reliable as relative indices of biomass. If they are right, then trends from catch data are actually misleading for the west coast of Vancouver Island, and provide no reassurance that bocaccio biomass is stable in other areas. If they are right, the only credible conclusion is that bocaccio biomass is declining at a biologically unacceptable rate in the single area that has been censused. This conclusion is consistent with listing decisions for stocks farther south, and with anecdotal reports for the Strait of Georgia and Puget Sound. Reviewer #1 pointed out that the authors (and DFO) must still advise COSEWIC whether this declining trend characterizes the species as a whole, or perhaps just a genetically distinct population (ESU) in southern BC-Washington. However, if there is no evidence to indicate that bocaccio occur in multiple ESUs, then COSEWIC will probably assess status for the whole species within Canada, taking into account that the IUCN global designation for bocaccio is Critically Endangered, implying a reduced opportunity for recruitment from US waters.

Reviewer #2

Reviewer #2 thought the Working Paper provided an excellent summary of the available data, including biases or shortcomings that affected the utility of these data. The graphic presentation of data was excellent. The data were thoroughly analyzed, but the conclusions lacked focus, primarily because the objectives of the paper were not clearly stated. If the paper is to be considered in a COSEWIC forum, the reviewer had only one serious criticism: the authors failed to recommend a status for bocaccio. The authors state that bocaccio are "not threatened" or overfished when considered coastwide, but don't indicate whether they are "Special Concern", "Data Limited" or "Not at Risk". The authors further assert that further review and analysis would be unlikely to improve the basis for harvest advice.

However, collection of additional data might. The reviewer suggested that the authors consider recommending development of synoptic trawl surveys in BC waters, as only the US triennial surveys had enough information to be considered useful. The reviewer noted that bocaccio is only one of a number of "non-TAC" species that will require preliminary assessment in the next decade. The authors might also recommend collecting biological data for bocaccio. The reviewer suggested an examination of size and age frequency distributions might influence the authors' opinion of stock status.

Subcommittee Discussion

There was considerable discussion around the conclusion of the paper that "there is nothing to suggest that the coastwide population of bocaccio is threatened or could be described as overfished". As presented by reviewer #1, the analysis of the west coast Vancouver Island shrimp survey data and, in particular, the US triennial survey data indicate a serious decline when viewed against ICUN or COSEWIC criteria. In this light, the Subcommittee felt that the authors should review the surveys in more detail to ensure uncertainty in the surveys is reported. In particular, plots of spatial distribution of tows in relation to commercial catch locations could be helpful.

A further concern was the spatial entity. It was indicated that from the COSEWIC perspective that entire west coast, perhaps including the U.S., would constitute a single stock entity. The authors felt that the stock status in the Strait of Georgia, off the west coast of Vancouver Island and in Queen Charlotte Sound could not be inferred from surveys off the lower west coast of Vancouver Island given low rates of mixing among areas.

Regarding the statements in the paper on stock status, it was pointed out that it is not appropriate for PSARC to make a COSEWIC status recommendation. The Subcommittee should only consider whether the data are complete and interpreted correctly.

Industry representatives noted that the distribution of bocaccio is closely associated with Canary rockfish. They felt that Canary quotas provide indirect protection for bocaccio. They indicated that the triennial survey may not be a particularly good index of bocaccio given the species prefers hard bottom and the triennial survey uses a soft bottom trawl.

There was repeated support for the development of synoptic trawl surveys over more of the Canadian zone to monitor the status of stocks like this.

The Subcommittee was concerned that the decline of abundance indices for bocaccio derived from the west coast Vancouver Island shrimp survey data and, in particular, the U.S. triennial survey data indicate a serious decline.

Subcommittee Recommendations

The Subcommittee concurred with the authors that the stock status in the Strait of Georgia, off the west coast of Vancouver Island and in Queen Charlotte Sound could not be inferred from surveys off the lower west coast of Vancouver Island. The Subcommittee recommended a detailed review of all survey indices to assess trends in bocaccio abundance in other areas.

G2001-04: Inshore rockfish stock assessments for the West Coast of Canada in 2001 and recommendations for management in 2002.

K.L. Yamanaka, L. Lacko ** Accepted subject to revisions**

Summary

The available data for inshore rockfish stock assessment is insufficient to recommend species specific catch quotas for the five management areas on the Pacific coast of British Columbia. However, this document does provide evidence for significant negative fishing effects for yelloweye and quillback rockfish at research survey index sites and other fishing locations in BC. The level of fishing mortality at these index sites is likely indicative of inshore rockfish fishing mortality throughout BC. Given the biology of inshore rockfish, together with the inability to assess total catch and the evidence of excessive fishing mortality, it is recommended that a portion of the rockfish population in each management area be completely protected from harvest through spatial management, such as closed areas as a precautionary conservation measure. In addition, comparable reductions in fishing effort in the remaining areas open to fishing must be accomplished or exceeded if managers choose to remain with the status quo or begin the rebuilding of stocks. Improvements to catch data, stock monitoring indices as well as stock assessment methods must continue to ensure the possibility of an assessment of inshore rockfish stock status in the future.

Reviewers' Comments

Reviewer #1

The reviewer noted that the Working Paper summarized data from several disparate sources of information and did a good job of illustrating the historical inconsistencies in data recording for either species identification, fishing location and effort or discards. Since traditional stock assessment models were not used to estimate biomass and provide TAC, the reviewer suggested that the Subcommittee focus discussion on the use of existing scientific literature to select spatial refugia. The reviewer noted that the authors presented management options based on scientific literature for different areas that focus on spatial refugia but they did not indicate if a lowering of existing TACs are required in conjunction with the refugia. The reviewer

felt that the evidence in the age structure and catch curve analyses estimating total mortality (Z) for Bowie Seamount (relatively unfished) compared to the fished areas elsewhere does support the conclusions that inshore rockfish is being heavily impacted by fishing. The Strait of Georgia appears to be the most severe and the reviewer thought that the authors' recommendation for immediate management action was valid.

Reviewer #2

Reviewer #2 thought the Working Paper provided a very thorough summary of the available information on inshore rockfish landings, size and age frequency, and CPUE. Although the assessment is supposed to cover copper, black, china, tiger, yelloweye and quillback rockfishes, abundance indices and management advice are presented only for yelloweye and quillback. Whatever information is available on the other species should be included along with some indication of whether stocks are likely to be healthy, overfished, or in decline. If the objective of this report is to provide a scientifically defensible summary of available information and interpretation of it's meaning, then the reviewer felt that they have done a very good job, at least for yelloweye and quillback. However, if the objective of this exercise is to protect the resources from overfishing by providing the best management advice that the data will allow, then the reviewer believed more could be done. The reviewer agreed that the available data support the conclusions and recommendations in the Working Paper.

Subcommittee Discussion

The Subcommittee agreed that there is a serious conservation concern for inshore rockfish. The Subcommittee acknowledged several factors of potential concern: 1) evidence for a history of progressive fleet movement to more remote grounds presented in the Working Paper, that may indicate serial depletion in the Strait of Georgia; 2) large exploitation effects evident in the catch curve analyses presented in the Working Paper; 3) the low natural mortality rates of <2% reported in the Working Paper that indicate harvest rates of <1% likely are sustainable; and 4) experience in the lower 48 US states demonstrating impacts of fishing on age structure in experimental areas.

The Subcommittee recognizes the progress made on a number of issues related to inshore rockfish research and management. These include implementation of rockfish protection areas, observer programs, and data collection and archiving programs. The lack of reliable catch statistics, however, is a serious impediment to quota-based management of inshore rockfish. This issue has been identified in each previous assessment. Although some improvements in catch reporting have occurred in the last few years, the data are insufficient for stock assessment purposes. As noted by Reviewer #1, the Working Paper did not provide quota-based yield options based on target biomass or exploitation rates because estimates of biomass are not available.

The Subcommittee agreed with the authors and reviewer #1 that the feasibility of harvest refugia for conservation be assessed as an adjunct to management of inshore rockfish. The Subcommittee also noted that existing scientific literature and in particular the NOAA workshop on harvest refugia for west coast rockfish referred to in the Working Paper are useful starting points for identifying suitable refugia for rockfish in BC. One participant commented that implementation of harvest refugia in other jurisdictions has been expensive as a result of increased monitoring and enforcement costs. Experience in New Zealand has shown that non-monitored refugia experience high poaching activity. There was a suggestion that the transfer of property rights and associated enforcement costs to fishermen in protected areas is one option to reduce public costs.

The Subcommittee concurred with the authors and both reviewers that development of stock monitoring programs and reliable abundance indices are an important component of inshore rockfish assessment. The Subcommittee also emphasized that estimates of catch by species were necessary, but are not sufficient alone to produce reliable assessments of inshore rockfishes.

Subcommittee Recommendations

1. The Subcommittee agreed that there is a serious conservation concern for inshore rockfish. The Subcommittee noted that current quota-based management for the directed Zn fishery does not provide sufficient protection against detrimental fishing effects and may fail to meet conservation objectives. The Subcommittee recommended that research efforts for inshore rockfish species be directed to evaluating the design and potential of harvest refugia as an adjunct to quota management.

2. The Subcommittee recommended improvement of catch data for all inshore rockfish in all fisheries. Specific improvements include: 1) obtaining catch data from commercial hook and line, recreational and First Nation fisheries by species, 2) recreational monitoring programs should consider designs appropriate for all species, and 3) expanding the recreational monitoring programs to encompass catch coastwide.

3. The Subcommittee recommended the initiation of stock monitoring programs and development of population indices in conjunction with harvest management initiatives. The Subcommittee recommended stock monitoring with research surveys, biological sampling programs and development of non-intrusive visual methods.

G2001-05: A phase '0' review of elasmobranch biology, fisheries, assessment and management.

A.J. Benson, G.A. McFarlane, J.R. King **Accepted subject to revisions **

Summary

Elasmobranch catches (skates, rays and sharks) in BC averaged 550 t in the 1970s and 1980s and increased to a maximum of 1,850 t in 1997. The average catch between 1998 and 2000 was 1,400 t. This trend mirrors the global elasmobranch catches that have risen steadily from an average of 200,000 t in the 1940s to over 800,000 t in recent years. The increased catches reflect the growing interest in directed elasmobranch fisheries that is the result of emerging markets. Fisheries and Oceans Canada (DFO) acknowledges the need for a scientifically defensible approach to the development of new fisheries. A phased approach that is based on the precautionary principle is applied to these fisheries. The available information at each step is utilized for fine tuning management strategies and research needs. There are three steps in the process, designated as Phases 0, 1, and 2. This report is a Phase 0 study that is intended to address questions raised by managers and that will form the basis for subsequent research and management actions. The questions asked are:

1. What is known about the biology and productivity of skates and sharks that are caught in BC waters and/or other jurisdictions?
2. What is known about the biomass and stock size structure of BC skates and sharks and how does this relate to historical stock conditions?
3. What are the appropriate harvest levels, given the biology and status of skates and sharks?
4. What information is available on the bycatch and associated mortalities, of skates and sharks in other fisheries?

There are three species of ray, eight species of skate, and fourteen species of sharks that are present in BC waters, but only big skate (*Raja binoculata*), longnose skate (*Raja rhina*), black skate (*Bathyraja interrupta*), and sixgill shark (*Hexanchus griseus*) are regularly taken as bycatch in BC fisheries. Of these, big skate is the most important, and represents 70% of the total sorted elasmobranch catch over the past 4 years. The majority of the catches are taken in Hecate Strait. A review of the biology of elasmobranchs is presented and indicates that the largest species are the most vulnerable to exploitation. Based on this, big skate is probably the least resilient BC species.

Research needs that must be addressed for improved assessment and management are: determination of the number and geographical limits of BC elasmobranch populations, the development of ageing methods for these species, and obtaining accurate life history parameters for BC elasmobranch species. The

Working Paper recommended improved catch statistics, species specific size limits and capping skate catches at the median level of the past four years.

Reviewers' Comments

Reviewer #1

Reviewer #1 noted that the objectives of the paper included gathering information on biology, productivity, bycatch and associated mortalities of skates and sharks in general; gathering information on biomass and stock structure of skates and sharks in BC; and recommending appropriate harvest levels for skates and sharks in BC. In the reviewer's opinion, the first two objectives were addressed successfully, the latter was addressed by recommending skate catch ceilings in one area, but no harvest levels were proposed for sharks or other skate species. The recommendation to set ceilings depends on the authors' belief that the suggested TACs are sustainable and whether managers will invoke closure when one of the quotas is met. Reviewer #1 was concerned that relative vulnerability rankings within elasmobranch species were of limited utility because all were considerably lower than teleosts. The process does identify key species for assemblage management. With no information available on distribution or abundance of BC skates, the assumption that populations are not stressed because we can still catch large individuals of the largest species is somewhat tenuous. Predicting catches from 1996-2000 CPUE and 1954-1995 effort requires the assumption that CPUE did not vary over that time period and that effort was reported accurately. The authors note that it is important to monitor shark bycatch so that the future production of the most vulnerable species is not negatively impacted. Reviewer #1 questioned what information would be used to detect the effect of bycatch.

Reviewer #2

The reviewer concluded that the Working Paper was well written and addresses the key issues for elasmobranch fishes in Canadian waters. The reviewer thought the use of the r' (potential rate of population increase) value appears to be a relatively good "predictor" of susceptibility to fishing mortality and population decrease (or poor rebound capabilities). It seems that the r' value should be used cautiously until its overall relationship to r (intrinsic rate of population increase) can be quantified. Additionally, if one possesses the data necessary to calculate the r', then it is likely that they possess enough data to use life history tables or a form of stochastic demographic modeling (either density-dependent or independent). In cases where that does not hold true, the r' may prove extremely useful. The reviewer commented on stochastic modeling analyses of shark populations in other jurisdictions.

Subcommittee Discussion

The Subcommittee accepted the conclusions of the Working Paper that recent increased catch of skates in BC is a concern and agreed that managers should consider area-specific catch limits.

An industry member highlighted historical features of skate catch in the groundfish fishery and concluded that the big skate catch estimates appear reasonable. Prior to 1996, no market existed for longnose skates, and the species was discarded. Generally speaking, the catch records probably do not include these discards.

Some portion of discarded skates may survive, and thus not contribute to fishing mortality. Because longnose skates often occur with Dover sole, industry participants suggested that the TAC for Dover sole acts to limit the longnose skate catch. A small longnose skate TAC could have serious consequences to the fishery, due to the potentially limiting role of this species as bycatch in the IVQ system.

The authors noted that current analyses use projections of combined landings and discards. If the catch history is incorrectly captured, the interpretation of the median catch as being sustainable may be incorrect. Subcommittee members expressed various opinions about catch estimates. Only observed data could be used or an attempt to estimate the unreported catch prior to 1996 could be undertaken. The Subcommittee was concerned that five years of catch data does not provide adequate information to establish a sustainable catch level.

Subcommittee members raised a number of questions about the paper's recommendations. For example, why are caps suggested for area 5D, but not area 3C? Could managers exercise some flexibility, such as adopting the maximum, rather than median, historical catch? Should caps be we recommend in a phase '0' document? Managers stated that caps would be translated to TACs for the fleet, in a manner designed to avoid "fear fishing", that is, sudden catch increases as individual vessels try to establish a precedent for a larger share of quota allocation. The authors cautioned against using the maximum catch as a cap, given the recent apparent increase in catch.

Subcommittee Recommendations

The Subcommittee accepted the conclusions of the Working Paper that recent increased catches of skates in BC to an average of about 1500 t in 1996 to 2000 from a historical average of 382 t is a significant change despite presumed under-reporting between 1954 and 1995. The skate fishery has reached a level where managers should consider caps for all species in all areas, taking account of the IVQ context and related fishery impacts.

G2001-06: Assessment of Pacific cod off the West Coast of Vancouver Island and Hecate Strait, November, 2001.

A. Sinclair, S. Martell, J. Boutillier ** Accepted subject to revisions **

Summary

Area 3CD, West Coast Vancouver Island

Annual total allowable catches (TACs) were introduced in this area in 1994. None of the TACs were attained. In 1994, 56% of the TAC was taken, in 1995 50% was taken. Since then, less than 20% of the annual TACs were taken. The TAC plus carry forward in 2000-2001 was 894 t, and the reported landings for the period was 130 t.

The catch per unit effort series had several peak periods, in the mid-1960s, the early 1970s, the late 1970s, and the late 1980s. The series declined in the early 1990s and reached an historic low in 1998. Since then, there has been an increase to 2001. The most recent value is less than half the long-term average. A Pacific cod biomass index calculated from shrimp surveys off the west coast of Vancouver Island was in general agreement with the commercial catch per unit effort index.

A delay-difference stock production model was used to estimate stock parameters relevant to management. The model predicted 3 main peaks in biomass, in 1965 (17,000 t), 1972 (25,000 t) and 1989 (12,000 t). Biomass declined following the third peak and reached an historical minimum of 2,123 t 1996. The predicted biomass increased somewhat thereafter, reaching 4,511 t in 2001, but this was below previous minima in the 1980s and 1960s. Peaks in biomass were all preceded by peaks in recruitment. Predicted fishing mortality varied between 0.1-0.4 from 1956-1990 then increased sharply to between 0.7-0.9 from 1991-1995. This period of high fishing mortality corresponded with a series of low recruitment anomalies. In combination, this resulted in very low stock biomass and recruitment in recent years.

The model predictions indicate that for much of the time series (1956-1990) the fishing mortality was above F_{msy} and the biomass below B_{msy} (Fig. 2). Fluctuations in biomass during this period were largely due to variation in recruitment. Fishing mortality increased considerably in 1991 to values not seen before and the stock biomass declined sharply. There has been little increase in biomass in recent years despite a large reduction in fishing mortality. The point estimate of biomass in 2000 is approximately 25% of B_{msy}.

The results of deterministic catch projections are summarised in Fig. 3. A range of 2002 catches of 0-900 t was used. The catch in 2001 was assumed to be 200 t. Three criteria were investigated. The first was the change in biomass between the

beginning and end of 2002. With no catch in 2002, stock biomass is predicted to increase by 19%. A catch of approximately 390 t would result in no change in biomass and a catch of 900 t would result in a 25% decline in biomass. The second criterion was to compare the 2002 fishing mortality to F_{msy}. A catch of 250 t would result in F_{msy} while a catch of 480 t would generate a fishing mortality approximately twice F_{msy}. The third criterion was how close the surviving biomass would be to B_{msy}. With no catch in 2002, the surviving biomass would be approximately 23% of B_{msy} and a catch of 900 t would leave a biomass of 14% B_{msy}.

Recommendations

- Current stock biomass and recruitment are well below target. The current TAC plus carry forward is 893 t. Catches in this range in 2002 would result in a decline in stock biomass and further compromise stock rebuilding. If catches continue to be similar to those in recent years, i.e., less than 200 t, there may be improvement in stock biomass.

- The production analysis presented here could benefit from further investigation of the statistical properties of the various estimates. Of particular interest is the robustness of the biological reference point estimates. Various trial runs indicated the biomass and fishing mortality predictions were fairly robust, but the biological reference points, which depend largely on estimates of M and s_0, were quite variable. Thus, one should use these with caution.

Area 5CD, Hecate Strait

Annual total allowable catches (TACs) were introduced in the Hecate Strait area in 1992. With the exception of 1992, the landings have been below the TAC with between 39% (2000) and 85% (1998/1999) of the TAC being landed. The TAC was reduced to 200 t in 2001-2002 due to very low stock biomass estimated in the November 2000 stock assessment. At that time, there was a substantial portion of the 2000-2001 TAC that was not caught. In order to avoid fishing this up during the remaining months of the fishing year, an agreement was reached between DFO and the groundfish trawl fleet to close all Pacific cod fishing grounds in 5CD, with the exception of the northern edge of Two Peaks, from February 6 - April 30, 2001. So far in the current fishing year, 31% of the 200 t TAC has been landed (as of Oct. 15).

A commercial catch per unit effort index was calculated for the period 1954-2000. No index was calculated for 2001 because of the winter closure and the apparent avoidance of cod fishing grounds in the spring. Three major peaks occurred in Pacific cod density, in the mid-1960s, the mid-1970s, and the late 1980s. Catch per unit effort declined since the last peak and reached an historic low value in 2000.

Tyler and Crawford tested several possible environmental stock recruitment functions for this stock including circulation, temperature, herring as prey for young cod, and herring as prey for spawners. They concluded that the circulation hypothesis was the most effective in explaining recruitment anomalies for the stock. Sea level at Prince Rupert during the spawning period (January-March) was used as an index of circulation. High sea levels indicated high circulation through Hecate Strait and this resulted in low recruitment success. Sea level was below average during the early 1970s and late 1980s and above average in the early 1980s and most of the 1990s. Sea level in 2000 was about average and the most recent value in 2001 was below average.

The implications of these variations in sea level on stock production were investigated using a delay-difference production model. Inclusion of sea level as a covariate improved the model fit, in particular that of the predicted catches. The model without sea level produced a lower productivity estimate, i.e. slope at the origin of the stock recruitment curve, had higher B_{msy} and lower F_{msy} estimates than the model with sea level. This essentially shifted the management goal posts while not affecting the estimated stock trajectory (Fig. 4). The effect of variation in sea level height on production was investigated by estimating equilibrium yield curves when sea level was +- 0.5 standard deviation of the mean sea level (similar to variation in the 5-yr mean sea level). These results indicate that if sea level anomalies persist over several years, as has been observed in previous years, it may be prudent to shift target fishing mortality and biomass lower. Current sea levels are near average.

Deterministic catch projections using the results of models without and with sea level effects and a catch range of 0-1500 t were done. Three criteria were investigated. The first was the change in biomass between the beginning and end of 2002. With no catch in 2002, stock biomass is predicted to increase by between 30% and 45% in the two respective models (Fig. 5). A catch of 1000 t and 1200 t would result in no change in biomass in the respective models. The second criterion was to compare the 2002 fishing mortality to F_{msy}. Catches of 600 t and 750 t would result in F_{msy} in the 2 models. The third criterion was how close the surviving biomass would be to B_{msy}. With no catch in 2002, the surviving biomass would be approximately 20% and 40% of B_{msy}.

Recommendations

- Current stock biomass and recruitment are well below target. If the current TAC of 200 t is maintained for 2002, the stock biomass may increase by 25 - 35 %, allowing some stock rebuilding.

- This assessment depends to a large extent on the commercial catch per unit effort series as an index of stock size. It is clear that the fishery in the second

quarter of 2001 was conducted in areas of low cod abundance in order to avoid premature closure of other fisheries. It is very important to establish a fishery independent index of stock size in this area to replace the catch per unit effort series.

As for the area 3CD assessment, further investigation of the robustness of the biological reference point estimates is needed. The biological reference points, which depend largely on estimates of M and s_0, were quite variable. Thus, one should use these with caution. A second weakness is failure to account for changes in mesh size in the model and the effect this may have on recruitment estimates.

Reviewers' Comments

Reviewer #1

Overall the reviewer found the paper to be thorough. The conclusions regarding the low level abundance are well supported and warrant a continuing cautious approach to management of these stocks. Lack of a monitoring program hinders the assessment and the reviewer suggested that further work be limited until information from a monitoring program are available. In revisions to the Working Paper, the reviewer suggested the authors add some discussion of the impact of mesh sizes on the results for both stocks. For the west coast Vancouver Island stock, it is not clear why the TAC's changed in the last 2 years when there was no scientific advice provided. This should be clarified. CPUE is central to the assessment of the stock and the potential impact of management actions on fishing practices and CPUE should be examined in more detail in the future. It may be useful to look at qualifying the landings to focus on Pacific cod related landings. Fine scale display using a GIS may be helpful in determining any changes in spatial distribution of effort. Reviewer #1 thought that the catch projections are very informative. In the future some analysis of the probability distributions would be useful.

Reviewer #2

The reviewer thought the Working Paper convincingly demonstrates that biomass is low and that recruitment prospects are poor. He further stated that the understanding of production dynamics is poor and harvest strategy reference points are likely to be largely influenced by choice of stock-recruit relation and assumptions about growth. The terms of reference are systematically addressed in the Working Paper but perhaps insufficient guidance is provided regarding the recommendations for a monitoring program required for Hecate Strait Pacific cod. Comparison of the effort weighted CPUE and the swept area biomass index could be made with some indication of a preferred approach, as presenting both analyses of the same data is confusing. Insufficient information is provided to judge if growth, an important element of this assessment, is well determined for Pacific cod. There is no discussion regarding the merits and disadvantages of the delay difference model, in contrast to the surplus production model employed previously, and why the change

in models is justified. Further examination of the statistical properties of the estimates of the harvest strategy reference points is warranted before they are accepted for making fisheries management decisions.
The point estimates of forecasts could be enhanced by characterizing the uncertainty about these, however, this is unlikely to be of great importance until the resources rebuild somewhat. The Hecate Strait assessment suggests a fairly substantial percentage biomass increase if catches are limited. The reviewer stated this result needs to be reconciled with indications of poor recent and incoming recruitment. Fishery independent indices of abundance or biomass would add substantially to knowledge about the state of these resources, and is essential for the Hecate Strait stock. An index of year-class strength could assist in establishing recruitment trends and in exploring production dynamics with respect to stock-recruit relations.

Subcommittee Discussion

The Subcommittee accepted the conclusions that both the West Coast Vancouver Island and the Hecate Strait stocks are at historic lows.

The Subcommittee noted that the model of the Hecate Strait population is more optimistic than the model accepted by the Subcommittee in 2000. The Subcommittee accepted the results and noted that the change is mainly due to the adoption of a model which is considered to be more reflective of the population dynamics of this species. The primary model improvement was the inclusion of stochastic recruitment. This was considered important because the previous model assumed a deterministic recruitment.

The Subcommittee accepted the model of the Hecate Strait population which included environmental covariates and resulted in a better model fit to the data. The Subcommittee noted that the alternative model without the environmental covariate estimated less optimistic stock projections.

The Subcommittee noted that the west coast Vancouver Island population appears to have increased after implementation of closures to protect spawning aggregations. The Subcommittee also noted that there are alternative explanations for the increases seen in the late 1980s such as improved recruitment, independent of management actions.

The Subcommittee asked about recent trends in U.S. stocks at either boundary. There were some reports of increased catches of Pacific cod near Cape Flattery. The authors had not examined these data. They did comment that overall biomass levels were much higher in the Gulf of Alaska, and the recent trend in abundance was downward.

Some members asked whether the varying management regime might have affected the commercial CPUE trends. The Subcommittee noted that changes in management were unlikely to result in the magnitude of the downward trend.

The Subcommittee noted that the residuals in mean weight for Hecate Strait were showing a pattern in their deviations in recent years. The authors noted that this might have resulted from not incorporating the impact of a change in mesh size.

The Subcommittee asked for clarification on the biological mechanism for connecting Hecate Strait sea level to P. cod productivity. The authors noted that the paper by Tyler and Crawford argued that the high sea level indicated high transport through Hecate Strait, during the spawning season. This resulted in transport of eggs and larvae out of the area and subsequently lower recruitment.

The Subcommittee discussed the issue of "carry-overs". The authors commented that the over-riding issue was how many fish were killed. Whether it was TAC or TAC plus carry-over was immaterial.

Subcommittee Recommendations

1. The Subcommittee accepted the yield options presented in the paper for the WCVI stock (Table 1). The WCVI stock biomass has declined well below the B_{MSY} target reference point presented in the paper and in 2001 was estimated at 18% of B_{MSY}. The decline is the result of high fishing mortality in 1991-95 and low recruitment. Fishing mortality has since been reduced and the population indices now show an increasing trend. In the absence of fishing in 2002 the biomass in 2003 is predicted at 23% of B_{MSY}.

2. The Subcommittee accepted the yield options presented in the paper for the Hecate Strait stock (Table 2). Hecate Strait biomass has declined well below the B_{MSY} target reference point presented in the paper and in 2001 was estimated at 21% of B_{MSY}. The decline is the result of high fishing mortality in 1991-95 and low recruitment. Fishing mortality has since been reduced. In the absence of fishing in 2003 the biomass is predicted to increase to 41% of B_{MSY}.

3. The Subcommittee recommends the implementation of a multi-year monitoring program in Hecate Strait beginning in 2002 to replace the loss of abundance indices derived from fishery data.

G2001-07: Information on non-target species in the International Pacific Halibut Commission standardized stock assessment survey.

A.R. Kronlund ** Accepted subject to revisions**

Summary

Surveys of the major fishing grounds for Pacific halibut (*Hippoglossus stenolepis*) have been conducted by the International Pacific Halibut Commission (IPHC) since 1963. These surveys provide catch rate information used as an abundance index in the catch-at-age stock assessment of Pacific halibut. Although the surveys were optimized for obtaining distribution, abundance and biological data for Pacific halibut, data for non-target species were recorded throughout the survey area. The objectives of this analysis are (1) to describe the amount and distribution of non-halibut species encountered by the surveys and, (2) to investigate the prospects for developing abundance indices for non-halibut species. As part of this analysis, the adequacy of sampling procedures for non-target species currently applied by the IPHC was studied. Specifically, total survey catch was estimated, as well as catch rate and spatial distribution, for selected rockfishes (*Sebastes sp.*), spiny dogfish (*Squalus acanthius*), sablefish (*Anoplopoma fimbria*), arrowtooth flounder (*Atheresthes stomias*), and Pacific cod (*Gadus macrocephalus*). Analysis of survey data suggested that the IPHC survey might be more appropriate for developing an abundance index for spiny dogfish and sablefish than for other species.

Reviewers' Comments

Reviewer #1

The reviewer thought the author has done an excellent job on the task assigned and suggested minor revisions. The report could be faulted for not providing firmer recommendations, but the cost/benefit analysis of spending additional resources should be reviewed collectively.

The reviewer agree that the survey might provide a reasonable index of yelloweye and/or redbanded rockfish for the survey area; but, these are not necessarily the populations being fished by the commercial rockfish fishery in BC. However, the work suggests that a dedicated rockfish longline survey might be effective. The reviewer suggested that the author provide some opinion as to whether DFO should start to ramp up towards a formal rockfish longline survey.

With respect to using the survey in conjunction with halibut fishery logbook data; this process might be useful for generating crude extrapolations of rockfish bycatch. With respect to identifying areas of high bycatch of rockfish, the reviewer suggested a meeting with a small group of fishers would do the job. The author notes that the survey could provide useful indices for dogfish and sablefish. The reviewer concurs,

but is not apparent that it would be any more useful than the Hecate Strait survey or the commercial trawl data.

Reviewer #2

The reviewer felt that this was a very thorough and well-written working paper. The author has addressed relevant issues and provided his recommendations regarding the utility of these data for groundfish stock assessment. The analytical results are clearly presented in both a written and a visual context. IPHC data extend back to 1963 but there have been changes to the survey design and sampling scheme during that time and the catch of other species was not recorded until the early 1990s. The changes include changes to the spatial design as well as gear changes. These changes impair the interpretation of these data among years. The reviewer noted that the author included a very enlightening discussion of probability sampling to survey design.

Subcommittee Discussion

The Subcommittee agrees with the author's conclusion that the Standardized Stock Assessment (SSA) survey cannot be used as an index of inshore rockfish abundance and that a dedicated survey for inshore rockfish may be a better alternative. The Subcommittee also concurred with the author's conclusion that the SSA survey might be a viable means for indexing spiny dogfish and sablefish.

The Subcommittee endorsed the author's conclusion that the SSA survey may provide a useful index of dogfish and sablefish abundance. It was also noted that the species composition data from this survey may provide useful information for ecosystem-level studies. While the allocation of additional resources to collect more species composition and size composition data would improve the survey's utility for these and other species, it may be more worthwhile to allocate these resources to a dedicated survey. Individual investigators are encouraged to review the utility of this survey for other assessments.

Subcommittee Recommendations

The Subcommittee agreed that the SSA survey cannot be used as an index of inshore rockfish but may be appropriate for spiny dogfish and sablefish depending on the objective. The Subcommittee recommended individual investigators assess the utility of the SSA surveys based on their research objectives.

G2001-08: Assessment of the Canadian longspine thornyhead (*Sebastolobus altivelis)* for 2001.

P. Starr ** Accepted subject to revisions**

Summary

A detailed compilation and analysis of the available data for longspine thornyheads (*Sebastolobus altivelis*) found in west coast Canadian waters was presented. This analysis was prompted by concerns over the rapid development of a new bottom trawl fishery directed at this species since 1996. An analysis of the available length frequency data from the commercial fishery showed that these distributions have been quite stationary over the four years of available data and between the traditional WCVI fishery and the new northern exploratory areas. Relative abundance indices estimated from CPUE data using general linear modeling methods showed a 25% decline in biomass over the five year history of the fishery. This level of change is consistent with previous population modeling for this species. This report suggests that current levels of fishing be allowed to continue while monitoring from the new independent biomass survey begun in 2001 and the current comprehensive level of fishery monitoring is continued. The report also notes that the most important additional research requirement for this species is to acquire an understanding of the growth rates and productivity of this species.

Reviewers' Comments

Reviewer #1

The reviewer expressed concern that the analyses presented were not clearly linked to a stock assessment strategy for longspine thornyheads. The main points of the review were that:

1. Based on current understanding of the length-age relationship and suspected low precision of the ageing methodology, the length frequency analysis is unlikely to provide a timely or sensitive indicator of stock status;
2. Standardization of catch rates using a general linear model is an established and useful tool but has been applied without explicit statement of the modeling objectives, the exact form of the model, and the provision of adequate diagnostics;
3. Based on the description provided, the reviewer judged the interaction model to be technically flawed due to the inclusion of interaction terms without forcing the corresponding main effects to be included in the model fit. Since it cannot be determined whether the interactions are significant, the main effects model is suspect and may not provide the best possible explanation of variability in catch rates.

There was no support for the position that the current data collection protocols and exploratory fishing process would provide timely advice on stock status prior to fishing down of longspine thornyheads. The reviewer suggested that necessary elements of the Precautionary Approach were not implemented in the current management and assessment strategy, but supported the recommendation for studies of age determination and growth of longspine thornyheads.

Reviewer #2

The reviewer stated that the report is well written and the analyses appear to have been done thoroughly and competently. He found nothing to seriously question the validity of the results or the recommendations. The purpose of the Working Paper is clearly stated. The data and methods appear adequate to support the conclusions. The data and methods are explained in considerable detail. The recommendations are provided in a form that should be useful to a fisheries manager. The advice reflects the uncertainty in the data and analyses. The reviewer had no additional areas of research to suggest beyond those identified by the author.

Subcommittee Discussion

The Subcommittee agreed with the author's conclusion regarding the decline in biomass of approximately 25% for the assessed region off the south west coast of Vancouver Island. The Subcommittee expressed concern that this fishery has developed so rapidly in a short period, but also noted that measures have been taken which have reduced the catch in this area.

The Subcommittee noted that despite intensive data gathering effort from the current fishery, there is concern that the information will not be adequate to manage this species. The Subcommittee noted that the current management of both the traditional and exploratory fisheries is not designed to maximize the information gained from observing the effects of fishing. The Subcommittee suggests that a designed approach to obtain contrast in fishing effects would improve the information that could be obtained while fishing.

There was concern over the size of the exploratory fishery and the failure to implement an experimental design when this fishery was first proposed. It was suggested that the collection of size composition data would not be sufficient to provide signals of change in the exploratory fishery and that a more robust design which contrasted size composition data between lightly exploited areas and more heavily exploited areas might be of benefit. The Subcommittee noted that the west coast Vancouver Island research survey, which was conducted this year on longspines, would provide valuable information on abundance and biological characteristics of this species.

The Subcommittee expressed concern over the 25% decline in CPUE and suggests it could indicate overfishing in the traditional fishery if harvest rates associated with the decline were allowed to continue.

The Subcommittee expressed concern that the current exploratory fishery was not consistent with the policy on new and developing fisheries. The Subcommittee also expressed concern that the current data collection protocol and exploratory fishery design was not sufficient to halt stock decline to overexploited levels until after it happens.

Subcommittee Recommendations

1. The Subcommittee recommended that an experimental design be established for the longspine fishery to determine the population response to fishing. This work needs to be undertaken as soon as possible in collaboration with management, stakeholders and science.

2. The Subcommittee recommended that the current quotas of 425 t in each of the two fisheries for the 2002/2003 be continued for an additional year while an experimental design to test for the effects of fishing is developed. Part of the experimental plan should be consistent with government policy on new and developing fisheries. The Subcommittee also noted the continued decline of CPUE in the southern WCVI fishery and indicated that a drop in the TACs may be required even with the establishment of an experimental design.

G2001-09: An update for the British Columbia experimental fishery for Pacific hagfish (*Eptatretus stoutii*).

A. Benson, C.M. Neville, G.A. McFarlane ** Accepted subject to revisions**

Summary

A review of a recent experimental fishery for Pacific hagfish (*Eptatretus stoutii*) in British Columbia is presented. The fishery took place between May 2000 and June 2001 (the experimental fishery license was issued for May 2000-April 2002), and was restricted to Pacific Fishery Management Areas 23 and 123, inside and outside waters of Barkley Sound. Fisheries and biological data are described and historical records are updated. The available information is limited, but indicates that the current level of exploitation is not negatively impacting the stock. Because hagfish are slow growing and mature relatively late in life (8-10) years, caution in managing the fishery is advised. Continued restriction of the fishery to areas 23 and 123, and improved data collection is recommended.

Reviewers' Comments

Reviewer #1

Reviewer #1 thought the purpose of the paper is clearly stated: a review of the experimental hagfish fishery in Barkley Sound. The reviewer identified several potential deficiencies including the lack of an age determination method, uncertainty about life history characteristics and poor catch and effort data quality. The reviewer was concerned that although the assigned vessel was supposed to fish every month, this did not happen. The condition of license should be actively enforced. An analysis of why the fishing vessel skipped ½ of the required months might lead to a more reasonable design. The reviewer suggested that the authors could group the data by quarter or some other time interval greater than 1 month. Additionally, with CPUE values <1 kg/trap, it might make more sense to record landings in fish and CPUE in fish/trap. Low catch rates imply low population densities of hagfish. The Working Paper could have benefited from an analysis of the variability in the data. The reviewer suggested that the authors access other sources for independent variables and explore the effect of these on CPUE. Factors such as depth, tide and climatological indices might provide clues on CPUE fluctuations. The authors state, "the present level of exploitation is not negatively impacting this stock." The reviewer concluded that there is insufficient information to make this claim simply because stock size is unknown.

Subcommittee Discussion

The Subcommittee agreed with the reviewer's comments that the data are limited and that there is insufficient information on the current exploitation rate to support the authors' statement that "the present level of exploitation is not negatively impacting the stock". Further, no information is provided on stock size and the status of the stock is unknown.

A recommendation in the Working Paper stated that managers should continue to limit the fishery to areas 23 and 123 until sufficient information is obtained to assess the impacts of the current levels of fishing. The Subcommittee accepted the recommendation but agreed that the report should clearly indicate what is meant by 'sufficient information'.

Subcommittee Recommendations

Continue to limit the fishery to areas 23 and 123 until sufficient information is obtained to assess the impacts of the current levels of fishing.

G2001-10: Turbot stock assessment for 2001 and recommendations for management in 2002.

J. Fargo and P. Starr ** Accepted subject to revisions**

Summary

We present an analysis of biological data, research survey data and observer data for turbot (*Atheresthes stomias*). Results from the analysis of observer data indicate that the variability in the CPUE index from the commercial fishery is mainly due to area and seasonal effects (and in some cases depth) and that these variables can change among years. The analysis of the discard data indicates that this fishery appears to be passive with little evidence of targeting behaviour. The turbot CPUE index from research surveys conducted between 1984 and 2000 shows no trend but does show cyclic fluctuation over that period. Size and age composition data show no distinct trends over time. The instantaneous total mortality rate estimated from age composition data did not differ despite a twenty year exploitation history. We conclude that current total mortalities for turbot stocks off the west coast of Canada are at or below sustainable levels.

Reviewers' Comments

Reviewer #1

Reviewer #1 noted that the commercial catch per unit effort GLM analysis was done separately on the kept and discarded portions of the catch. He thought this was inappropriate. It would have been more interesting to see an analysis of the combined kept and discarded catches between 1996-2001. Turbot are widely distributed throughout the area, taken mainly as by-catch, retained when appropriate markets exist and when caught toward the end of a fishing trip. There is no quota-related reason to avoid turbot. An analysis of either the kept or discarded portions of the catch would probably be reflective of market conditions while an analysis of total catch per unit effort would be a better indicator of stock status. Such an analysis would have to be restricted to years where accurate total catch estimates are available, namely 1996-present. An illustrative analysis of total catch rates indicated an increasing trend over this time period.

Reviewer #1 stated that any conclusions drawn from analyses of catch curves should be accompanied by clear statements of their limitation. In this paper, catch curves were presented for two times, 1980 and 1997-2001. The slopes of these catch curves, which are used as the estimates of total mortality, would have been determined by events that occurred several years before the data were collected. Little can be said about changes in exploitation that might have occurred in the 17 - 20 years between the two data collections. The catch curve slope is also sensitive to changes in recruitment and selectivity. A statement that there has been no

detectable change in exploitation should be accompanied by a power analysis which demonstrates the magnitude of a change that might be detected with the data.

Reviewer #1 noted that there are some indications that turbot stock size in the Hecate Strait area has been affected by changes in fishing. The research survey index increased from 1984 - 1989, declined to a minimum in 1993, then increased again to 2000. The decline between 1989 - 1993 corresponds to a large increase in total fishing effort in Hecate Strait reported in previous assessments. The subsequent increase in the index, and the increase in the commercial catch rate of turbot, occurred after the total fishing effort in Hecate Strait was reduced by about 50%. The reviewer stated that it is likely such changes in fishing effort would have had an effect on turbot in this area, and the changes in biomass indices appear to support this.

Reviewer #2

Reviewer #2 felt the Working Paper contained a good synthesis of the biological information and catch statistics for turbot in the various management areas. The reviewer suggested a number of additions for completeness. Main concerns centered on the use of GLM models to explain variation in CPUE, without a discussion of the underlying assumption that for Turbot, CPUE is directly related to abundance. In addition, the reliability of the main conclusion, "that there is little trend in the CPUE data" is low (according to the authors). Yet this is used to substantiate the statement that current removals are sustainable. The reviewer pointed out that limited biological information is available for Hecate Strait and no information is available for other areas. Lastly, the reviewer suggested that further work should address the question "what are the effects on the ecosystem of removing Turbot", not " what are the effects of removals on Turbot stocks", i.e. examine ecosystem questions. Given the lack of biological data, low reliability of the catch/effort analysis and general lack of knowledge on ecosystem consequences, the reviewer suggested current levels of removal in Hecate Strait be considered a "cap", and in other areas recommended levels of catch should be lower than current removals.

Subcommittee Discussion

The Subcommittee accepted the authors' conclusion total mortalities for turbot off the west coast of Canada are at or below sustainable levels.

The Subcommittee agreed that the total turbot catch must be accounted for and that there appears to be data from the hook and line fishery that was not included in the Working Paper.

The Subcommittee discussed the calculation of the coastwide biomass estimates and the authors reiterated that they would not recommend the use of these biomass estimates for setting harvest levels.

Industry commented that there is an indication the level of discards in the current fishing year is lower than in previous years (approximately 3.0 million pounds less). They felt that the main reason for this was shorter trip length. The Subcommittee also noted that discard information prior to 1996 is unreliable because they were infrequently recorded.

The Subcommittee asked industry representatives what bycatch species were associated with turbot fishing. Industry representatives responded that turbot are caught along with a wide range of species. The Subcommittee felt that although there is a concern about turbot, there is an ecological effect on other species and that managers should be aware of this.

The Subcommittee noted that the spatial distribution of discarded catch presented in the Working Paper is greater than that of retained catch. One author noted that discard catch rates are lower. One participant commented that turbot are usually discarded unless caught close to the end of a trip. The Subcommittee acknowledged the efforts of industry to reduce the level of discards and encouraged them to continue those efforts.

The Subcommittee discussed some discrepancies in the way data were reported, in particular, some catches were reported by calendar year and some by fishing year.

Subcommittee Recommendations

The Subcommittee accepted the conclusion that removals of arrowtooth flounder off the west coast of Canada are at or below sustainable levels. The Subcommittee recommended that catch limits based on the average annual catches over the last four years be considered.

G2001-11: Pacific Ocean perch assessment for the West Coast of Canada in 2001.

J. Schnute, R. Haigh, B. Krishka and P. Starr ** Accepted subject to revisions**

Summary

Pacific ocean perch (*Sebastes alutus*, commonly called POP) dominate the rockfish catch in Canada's Pacific groundfish trawl fishery. The species belongs to a larger community of slope rockfish species that inhabit the sloping walls of marine canyons along the coast of British Columbia. This report compiles the scientific data currently available for POP and evaluates its relevance to setting quotas. Following the rationale in the 1997 assessment, we present an updated catch-age analysis for the Goose Island Gully (GIG) stock and extend these results to the rest of the coast.

Our analyses take account of spatial distributions and other biological features investigated in slope rockfish stock assessments since 1998.

Our catch-age analysis indicates that the GIG stock currently experiences low recruitment at age 7, possibly associated with an ocean climate regime starting in 1988. We urge caution in setting quotas, so that adequate biomass remains for the future when productivity improves. Our coastwide analysis suggests that the current quota distributions among management areas match available biomass levels fairly well, although we find some opportunities for quota redistribution.

Our models contain many debatable elements, but we are constrained by available data. We have relatively few research surveys, and most data come from the fishery itself. We use graphics and intuitive discussion to engage stakeholders in thinking actively about the current state of our knowledge. We suggest various options for setting quotas, including maintenance of the status quo.

We also highlight opportunities for future data collection, standardization, and quality control. In particular, we recommend fishery-independent surveys to obtain age distributions that include young fish aged 3–5. Data from such surveys would provide leading indicators of recruitment to the fishery at age 7.

We conclude that the GIG stock is currently experiencing low recruitment (Fig. 6). The risk analysis suggests caution in setting quotas.

Reviewers' Comments

Reviewer #1

The reviewer commented that as with any analyses of fisheries data, the authors had to make assumptions to produce inferences about POP stock size. The worth of their work is related to the quality of the data they used and the validity of their assumptions. In terms of their catch-age analysis, the authors made assumptions about important parameters such as the fishery age-selectivity and the selectivity of survey indices that appear debatable. The authors also made an assumption about the relationship between recruitment variability and survey variability that seems to have no scientific basis. It is important to understand how sensitive the catch-age estimates of POP stock status are to these assumptions. In terms of the author's "swept-area" analyses, more investigation may be useful to verify the relationship between CPUE and POP abundance. The measurement of effort can be difficult, and its relationship with catch may not be linear. Also, extrapolating CPUE to areas not fished is difficult. Many fisheries scientists are reluctant to use time-series of CPUE directly as indices of stock size, and if the POP fisheries share similarities with these other fisheries then the reviewer suggests that considerable caution is required when interpreting POP CPUE's.

Reviewer #2

In the reviewer's opinion, the document represents an imaginative and creative approach to maximizing the information to be obtained from the limited Pacific Ocean perch database. In addition to presenting the traditional assessment approach, the authors present several alternative methods to assess the stock. While this may result in greater discussion, it does provide a broader basis for evaluating the stocks. The document focuses primarily on the analytical aspects of the assessment and the methodology employed. In general, the approach utilized is well described, however, the level of detail provided can be confusing at times. A general shortcoming of the document is the failure to provide a discussion of the biological rationale for the analysis. For example the authors propose a new division of the coast which appears to represent discrete POP "units". However, there is no discussion of the biological significance of the divisions. Is each a separate stock or is the entire coast a meta-population. If each is discrete, it has implications for the broad applicability of findings (primarily from 5AB) to the entire coast.

Similarly, there is no discussion of the behavioural or biological factors, which can influence the CPUE. The problems with using CPUE have been noted with many fisheries. There are obviously habitat preferences for the rockfish with the highest catches coming from areas with the highest CPUE. With changes in abundance will the fleet activities change and artificially keep CPUE high? Are there differences between areas, particularly in the more northern areas? In previous papers the slope rockfish have been described as a community resulting in mixed catches. The document does not state if CPUE is only for POP or does the presence of other species influence CPUE.

Much discussion in the paper relates to regime shifts and the impact on productivity. Productivity should be defined and the mechanism for influencing future recruitment explained. It is interesting to note that even within periods of good productivity, recruitment fluctuates. Can anything be said about the earlier peak in 1970? The reviewer concurs with the overall conclusion that we need to be cautious. Long-lived species such as perch cannot sustain high levels of exploitation.

Subcommittee Discussion

The Subcommittee accepted the conclusions of the Working Paper that the Goose Island Gully stock is currently experiencing low recruitment (Fig. 6) and the risk analysis that suggests caution in setting quotas.

An alternative model of productivity within regimes was proposed in contrast to that presented in the Working Paper. The alternative entailed using different steepness and carrying capacity parameters within different regimes. The authors emphasized that their analysis indicated a decline in the POP stock regardless of exploitation rate; this decline is consistent with the life history strategy of POP in which large

recruitment events are episodic. It was mentioned for some fish populations that years of above average recruitment were independent of stock size; small spawning biomass could result in large year classes. The authors replied that in other cases small spawning stocks have produced recruitment failure, and recommended caution against reducing the population below an unknown critical threshold.

The point was made that there is extensive literature on optimal management under conditions of correlated recruitment that might assist in finding an appropriate harvest rate in the context of some simulation modeling. Constant catch policies have been found to be disastrous, so it was recommended that simulations project the implications of different harvest rates within regime periods to examine the consequences. The authors acknowledged that such simulations might be useful, but this year's assessment focuses on the current reality that the POP stock has low recruitment and consequently experiences natural decline. A non-constant catch policy would suggest quota reductions under these circumstances, precisely to avoid disastrous consequences. For this reason, the report recommends a cautious approach in the near future.

Contrary to the assessment, industry perception was that POP numbers and biomass were increasing and POP were encountered at all depths and locations (albeit in a period of poor recruitment). It was suggested that harvest rates were too low during the periods of high productivity. The point was made that the impact of management changes should not be ignored due to altered behavior on the part of fishers. A reminder was given that pre-1996 logbook data were of poor quality with suspect location information. It was also pointed out that the Tidemarks area has been subject to a spawning closure for the last 13-15 years that results in a significant closure of the coast for the October 1 to June 1 period. This closed area has not been monitored through fishery independent means and is a major omission from the assessment. In addition, the northern area (5E) does not represent a fringe of POP distribution, but rather part of the continuum of POP distribution into Alaskan waters. Industry put forth the belief that the IVQ system means that catch rates are held artificially low, and thus quotas cannot rise if based on catch rates. The authors pointed out that their assessment uses commercial catch rates only for distributing quotas spatially, not for determining temporal abundance indices. The Working Paper gives descriptions of all available fishery-independent surveys, and these are too spotty to substantiate industry's claims. The assessment is constrained by the available data.

General discussion ensued on a comment in the Working Paper that quota distributions might influence perceptions of relative stock biomass. Commercial catch rates, which reflect catches capped by existing quotas, might consequently suggest biomass levels consistent with the quotas. Further discussion centered on the designation of new areas, the combination of existing areas, and the consistency of interpretation of new area designations with historical management areas. It was recommended that area boundaries not be redefined without

appropriate examination of the historical rationale and implications for management of other species.

The large amount of foreign catch in the early recorded history of the fishery was noted. In particular, it was suggested that discarding of juveniles during the time of the foreign fishery could give the impression of a regime shift as fishing pressure was removed from juveniles with the exclusion of the foreign fleet. It was noted that new historical data on POP harvest, not previously accessible, might now be available from Russian sources.

As discussed in the Working Paper, the coastal allocation scheme from the Goose Island Gully stock assumes that all stocks move together and share common reference points. The authors emphasized the need for this assumption, given the absence of data to conduct an independent analysis in each management area. Current quotas from the 1997 assessment were allocated by a similar scheme, but without the benefit of detailed spatial data compiled in the observer database since then.

Subcommittee Recommendations

1. The Subcommittee accepted the conclusion of the Working Paper that there was no basis for increasing the current coastwide quota of 6148 t.

2. The Subcommittee supported the Working Paper recommendations for fishery independent surveys, synoptic sampling of fisheries, and data integrity projects. Furthermore, the Subcommittee recommended that a plan for obtaining fishery independent stock indices and biological sampling should be developed and implemented prior to completion of the next POP stock assessment. The lack of these data was identified by the Subcommittee as the major impediment to improvement of the stock assessment.

3. The Subcommittee recommended that prior to conducting another assessment, there should be significant progress on these issues. In particular, the Subcommittee recommended developing a fishery independent index.

A preliminary report on the development method to estimate the age of the longspine thornyhead rockfish

R.J. Beamish

The longspine thornyhead rockfish fishery is a lucrative, relatively new fishery. A method of determining the age of fish in the catch was needed to monitor the impacts of fishing and to estimate appropriate catch levels. The method developed in this study indicated that maximum ages exceeded 50 years, with age of fish in a commercial sample ranging from 18 to 55 years. Lengths common to commercial

catches would have ages ranging from 20 to 50 years, with little relationship between length and age.

The method developed required careful preparation of otolith sections and a selection of reference otoliths from very young fish. The preparation and interpretation of each otolith section takes about 1/2 hour. The interpretation of annuli from the section is complicated, but possible. The preliminary results are very similar to age estimates in another study in which the range of ages was proven to be accurate using radiochemical methods. This means that the age determinations in this preliminary study accurately estimate the age composition of the catch.

Considerable work remains. One difficulty is that there is uncertainty about the accuracy of the identification of the species that were sampled for otoliths. It is important that a key be developed that is based on the otolith shape, so that otoliths can be used to confirm that the species have been identified correctly. Another issue is the requirement to develop a new approach to estimating error. Eventually it will be necessary to develop an assessment model that is sensitive to the kinds of errors associated with the method, the species, and the skills of the age determination analyst.

APPENDIX 1: PSARC GROUNDFISH SUBCOMMITTEE MEETING AGENDA, NOVEMBER 13 – 16, 2001

PSARC Groundfish Subcommittee Meeting
November 13 - 16, 2001
Seminar Room, PBS, Nanaimo
Agenda

November 13

1. Opening remarks and introductions 9:00
2. G2001-02: An assessment of lingcod in the Strait of Georgia J. King. 9:30
3. G2001-07: Information on non-target species in the International Pacific Halibut Commission standardized stock assessment survey R. Kronlund. 11:30

Lunch 12:00

4. G2001-06: Assessment of Pacific Cod off the west coast of Vancouver Island and Hecate Strait, November 2001. A. Sinclair, S. Martell and J. Boutillier. 2:30
5. Progress on longspine thornyhead ageing R. Beamish. 4:30

Adjournment 5:00

November 14

6. G2001-08: Assessment of the Canadian longspine thornyhead *(Sebastolobus altivelis)*. P. Starr. 8:00
7. G2001-09: An update for the British Columbia experimental fishery for Pacific hagfish (*Eptatretus stoutii)* A. Benson, C. Neville and G.A. McFarlane 10:00
8. 2001-04: Inshore rockfish stock assessments for the west coast of Canada in 2001 and recommendations for management in 2002. K.L. Yamanaka and L. Lacko. 11:30

Lunch 12:00

9. Review of Subcommittee discussion from Day 1 2:30
10. G2001-10: Turbot Stock Assessment for 2001 and recommendations for Management in 2002. J. Fargo/P. Starr 3:30

Adjournment 5:30

November 15

11. G2001-11: Pacific Ocean perch assessment for the west coast. J.Schnute, R. Haigh, B. Krishka and P. Starr	8:00
12. G2001-01: Sablefish stock assessment for 2001 and advice to managers for 2002. R. Hilborn and M. Wyeth.	10:00
Lunch	12:00
13. Review Subcommittee discussion and advice for Day 2	1:00
14. G2001-03: Preliminary status report on bocaccio (*Sebastes paucispinus*) in BC waters. R.D. Stanley, K. Rutherford and N. Olsen.	2:30
15. G2001-05: A phase "0" review of elasmobranch biology, fisheries, assessment and management. A.J. Benson, G.A. McFarlane and J.R. King.	4:00
Adjournment	5:30

November 16

16. Review of Subcommittee discussion	8:00
Adjournment	4:30

APPENDIX 2: PSARC GROUNDFISH WORKING PAPERS FOR NOVEMBER 2001

G2001-01	Sablefish stock assessment for 2001 and advice to managers for 2002	V. Haist R. Hilborn M. Wyeth
G2001-02	Assessment of lingcod in the Strait of Georgia	J. R. King
G2001-03	Preliminary status report on bocaccio *(Sebastes paucispinis)* in BC waters	R.D. Stanley K. Rutherford N. Olsen
G2001-04	Inshore rockfish stock assessments for the west coast of Canada in 2001 and recommendations for management in 2002.	K.L. Yamanaka L. Lacko
G2001-05	A Phase "0" review of elasmobranch biology, fisheries, assessment and management	A.J. Benson G.A. McFarlane J.R. King
G2001-06	Assessment of Pacific cod off the west coast of Vancouver Island and Hecate Strait, November 2001	A. Sinclair S. Martell J. Boutillier
G2001-07	Information on non-target species in the International Pacific Halibut Commission standardized stock assessment survey	A.R. Kronlund
G2001-08	Assessment of the Canadian longspine thornyhead (*Sebastolobus altivelis*) for 2001	P. Starr
G2001-09	An update for the British Columbia experimental fishery for Pacific hagfish (*Eptatretus stoutii)*	A. Benson C.M. Neville G. A. McFarlane
G2001-10	Turbot stock assessment for 2001 and recommendations for management in 2002	J. Fargo P. Starr
G2001-11	Pacific Ocean perch assessment for the west coast of Canada in 2001	J. Schnute R. Haigh B. Krishka

APPENDIX 3: PARTICIPANTS AT GROUNDFISH SUBCOMMITTEE MEETING, NOVEMBER 13-16, 2001

Subcommittee Chair: Al Cass
PSARC Chair: Max Stocker

DFO Participants	TUES	WED	THURS	FRI
* Subcommittee Members				
Ackerman, Barry*		✓	✓	✓
Beaith, Brad	✓			
Beamish, Dick	✓	✓		
Bonnet, Terri	✓	✓	✓	
Cass, Alan*	✓	✓	✓	✓
Choromanski, Ed	✓			
Cormier, George	✓	✓	✓	✓
Dunsmore, Gerry	✓	✓	✓	
Eros, Carole*	✓	✓	✓	✓
Fargo, Jeff*	✓	✓	✓	✓
Haigh, Rowan*	✓	✓	✓	
Haist, Vivan			✓	
Hardy, Schon	✓	✓	✓	
King, Jackie*	✓	✓	✓	✓
Krishka, Brian	✓	✓	✓	
Kronlund, Rob*	✓	✓	✓	
Lacko, Lisa	✓			
Macdonald, Allan*	✓	✓	✓	✓
McFarlane, Sandy*	✓	✓	✓	✓
Moores, John*	✓	✓	✓	✓
Rutherford, Kate	✓	✓	✓	
Saunders, Mark*	✓	✓		
Schnute, Jon*	✓	✓	✓	
Sinclair, Alan*	✓	✓	✓	✓
Stanley, Rick*	✓	✓	✓	✓
Wright, Rob	✓	✓	✓	✓
Wyeth, Malcolm	✓	✓	✓	
Yamanaka, Lynne*	✓	✓	✓	✓
External Participants:				
Acheson, Chris			✓	
Anderson, Kelly		✓	✓	
Chow, Sharon	✓	✓		
Dickens, Brian	✓		✓	✓
Fraumeni, Bob			✓	✓
Jewsbury, Gail			✓	
Mose, Brian	✓	✓	✓	✓

External Participants cont'd				
Olsen, Erling		✓	✓	
Sporer, Chris		✓		
Starr, Paul	✓	✓	✓	✓
Turris, Bruce	✓	✓	✓	
Observers:				
Glavin, Terry			✓	
Hilborn, R.			✓	
Humphreys, Bob	✓	✓		
Lane, Jim	✓			
Martell, Steve	✓	✓		
Wallace, Scott		✓		

Reviewers for the PSARC papers presented at this meeting are listed below, in alphabetical order. Their assistance is invaluable in making the PSARC process work.

Berkeley, S.	Hatfield Marine Science Center
Cadigan, N.	Northwest Atlantic Fisheries Centre
Fargo, J.	DFO, Pacific Biological Station
Gavaris, S.	DFO, Biological Station, St. Andrews NB
Gillespie, G.	DFO, Pacific Biological Station
Goldman, K.	Virginia Institute of Marine Science
Haigh, R.	DFO, Pacific Biological Station
King, J.	DFO, Pacific Biological Station
Kronlund, R.	DFO, Pacific Biological Station
Marliave, J.	Vancouver Aquarium
Mcfarlane, S.	DFO, Pacific Biological Station
Moore, J.	DFO, Fisheries Science Branch, Ottawa
Sampson, D.	Hatfield Marine Science Center
Saunders, M.	DFO, Pacific Biological Station
Schwarz, C.	Simon Fraser University
Sigler, M.	NMFS, Auke Bay
Sinclair, A.	DFO, Pacific Biological Station
Stanley, R.	DFO, Pacific Biological Station
Wood, C.	DFO, Pacific Biological Station
Yamanaka, L.	DFO, Pacific Biological Station

TABLES AND FIGURES

Table 1. Yield options for West Coast Vancouver Island Pacific cod

Catch in 2002	F in 2002	Biomass in 2003	Change in Biomass	% of B_{msy} in 2003	% of F_{msy} in 2002
0	0.00	2884	19%	23%	0%
60	0.03	2811	16%	22%	22%
120	0.06	2738	13%	22%	46%
180	0.10	2666	10%	21%	69%
240	0.13	2594	7%	21%	94%
300	0.16	2522	4%	20%	119%
360	0.20	2450	1%	19%	146%
420	0.24	2379	-2%	19%	173%
480	0.28	2307	-5%	18%	201%
540	0.31	2236	-8%	18%	230%
600	0.36	2165	-11%	17%	260%
660	0.40	2095	-14%	17%	291%
720	0.44	2024	-17%	16%	324%
780	0.49	1954	-19%	15%	358%
840	0.54	1884	-22%	15%	394%
900	0.59	1815	-25%	14%	431%

Table 2. Yield options for Hecate Strait Pacific cod

Catch in 2002	F in 2002	Biomass in 2003	Change in Biomass	% of B_{msy} in 2003	% of F_{msy} in 2002
0	0.00	5295	45%	41%	0%
100	0.03	5161	41%	40%	12%
200	0.06	5027	37%	39%	25%
300	0.10	4893	34%	38%	38%
400	0.13	4759	30%	36%	51%
500	0.16	4626	26%	35%	65%
600	0.20	4493	23%	34%	80%
700	0.24	4360	19%	33%	95%
800	0.28	4227	15%	32%	110%
900	0.32	4094	12%	31%	126%
1000	0.36	3962	8%	30%	143%
1100	0.40	3830	5%	29%	160%
1200	0.45	3698	1%	28%	179%
1300	0.50	3567	-3%	27%	198%
1400	0.55	3435	-6%	26%	218%
1500	0.60	3304	-10%	25%	239%

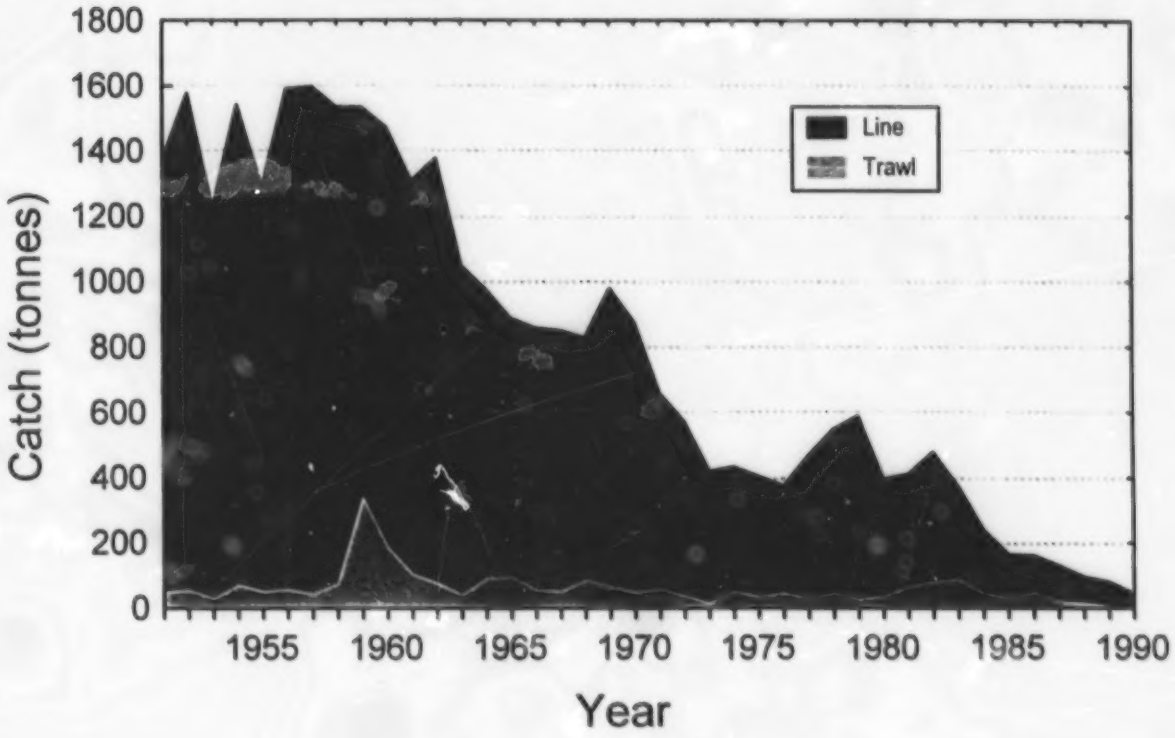

Figure 1. Lingcod catch (tonnes) for combined hook and line (handline, troll, longline) and trawl gear in Major Statistical Area 4B from 1951 to 1990.

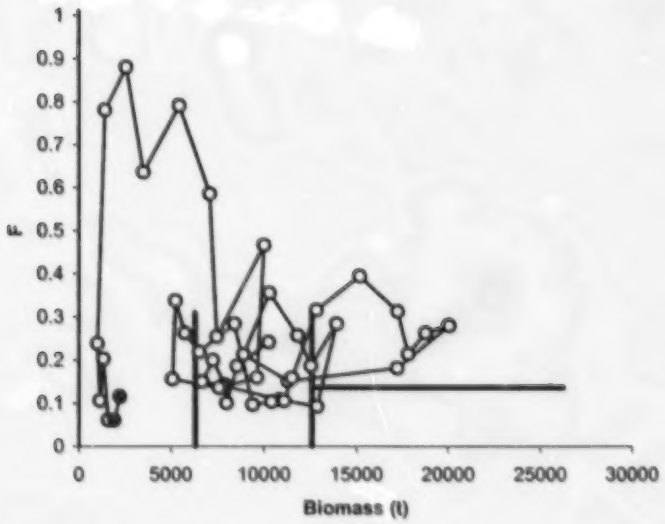

Figure 2: Phase plot of predicted biomass and fishing mortality for west coast Vancouver Island Pacific cod. The vertical lines begin at B_{msy} and $0.5\,B_{msy}$ and terminate at F_{crash}. The horizontal line is at F_{msy} and terminates at B_0. The final 2 years (2000, 2001) are indicated by solid circles.

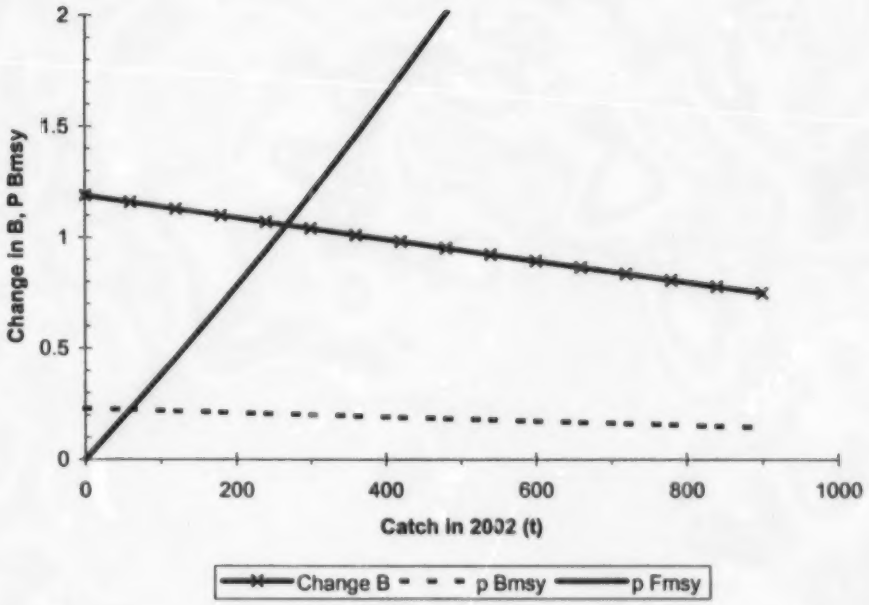

Figure 3. Summary of catch forecasts for west coast Vancouver Island Pacific cod. Three criteria are presented relative to the catch in 2002. The solid line with tick-marks gives the proportional change in stock biomass between 2002 and 2003. The dashed line indicates the proportion of F_{msy} that will result from the given catch. The solid line indicates the fraction of B_{msy} that will be present in 2003.

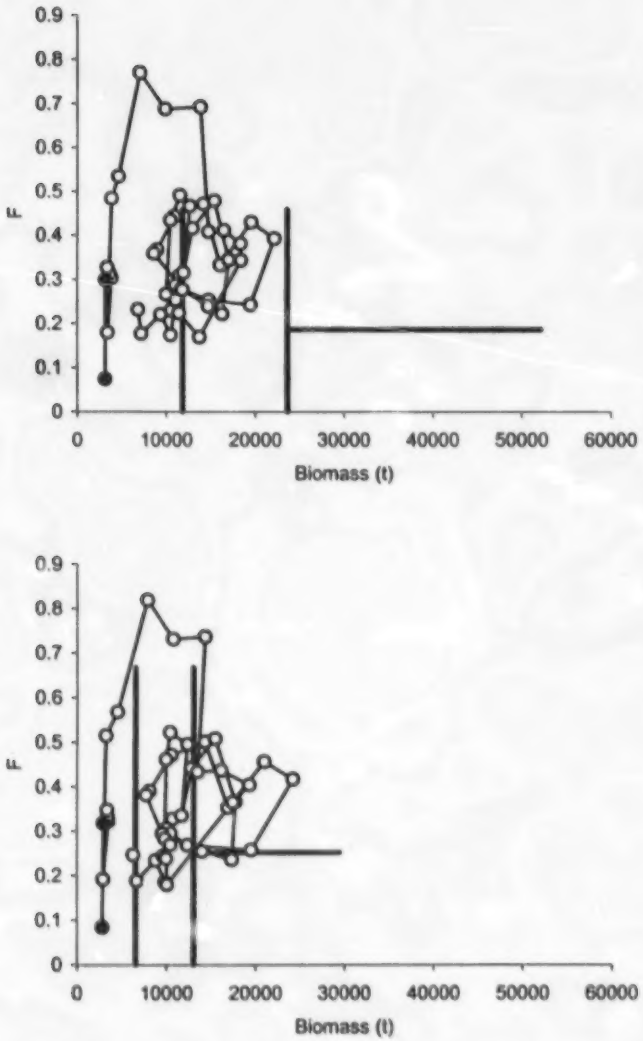

Figure 4. Trajectories of biomass and fishing mortality for area 5CD Pacific cod, estimated with delay difference models without (upper) and with (lower) sea level as a covariate. The vertical lines begin at B_{msy} and $0.5\,B_{msy}$ and terminate at F_{crash}. The horizontal line is at F_{msy} and terminates at B_0. The final 2 years (2000, 2001) are indicated by solid circles.

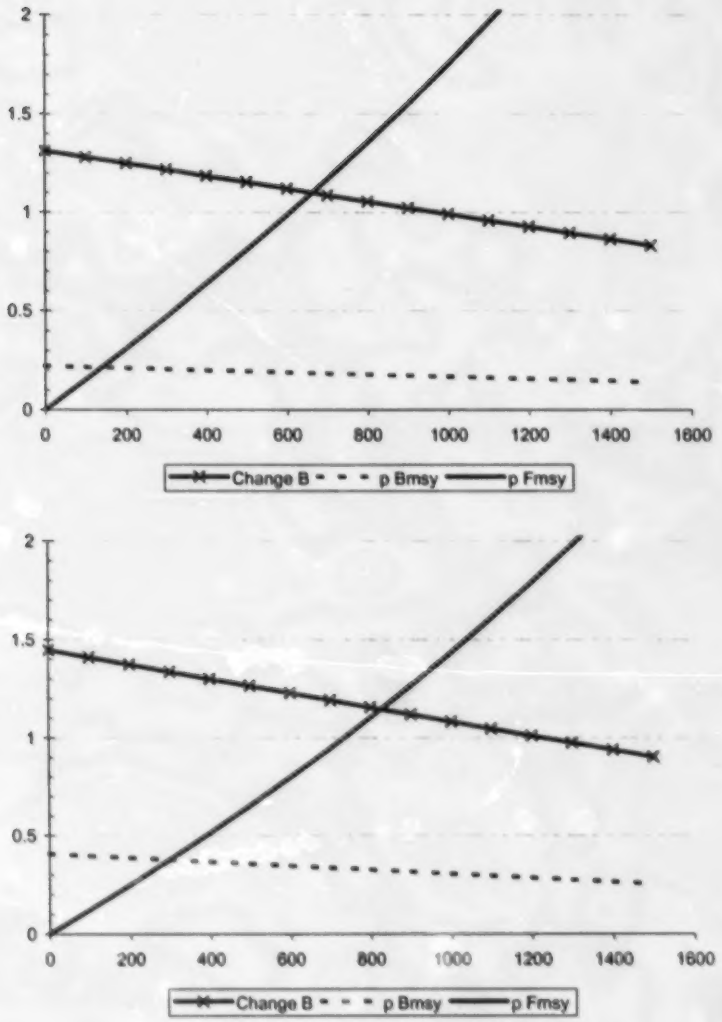

Figure 5. Summary of catch forecasts for area 5CD (Hecate Strait) Pacific cod from delay difference productions models without (upper) and with (Lower) sea level as a covariate. Three criteria are presented relative to the catch in 2002. The solid line with tick-marks gives the proportional change in stock biomass between 2002 and 2003. The dashed line indicates the proportion of F_{msy} that will result from the given catch. The solid line indicates the fraction of B_{msy} that will be present in 2003.

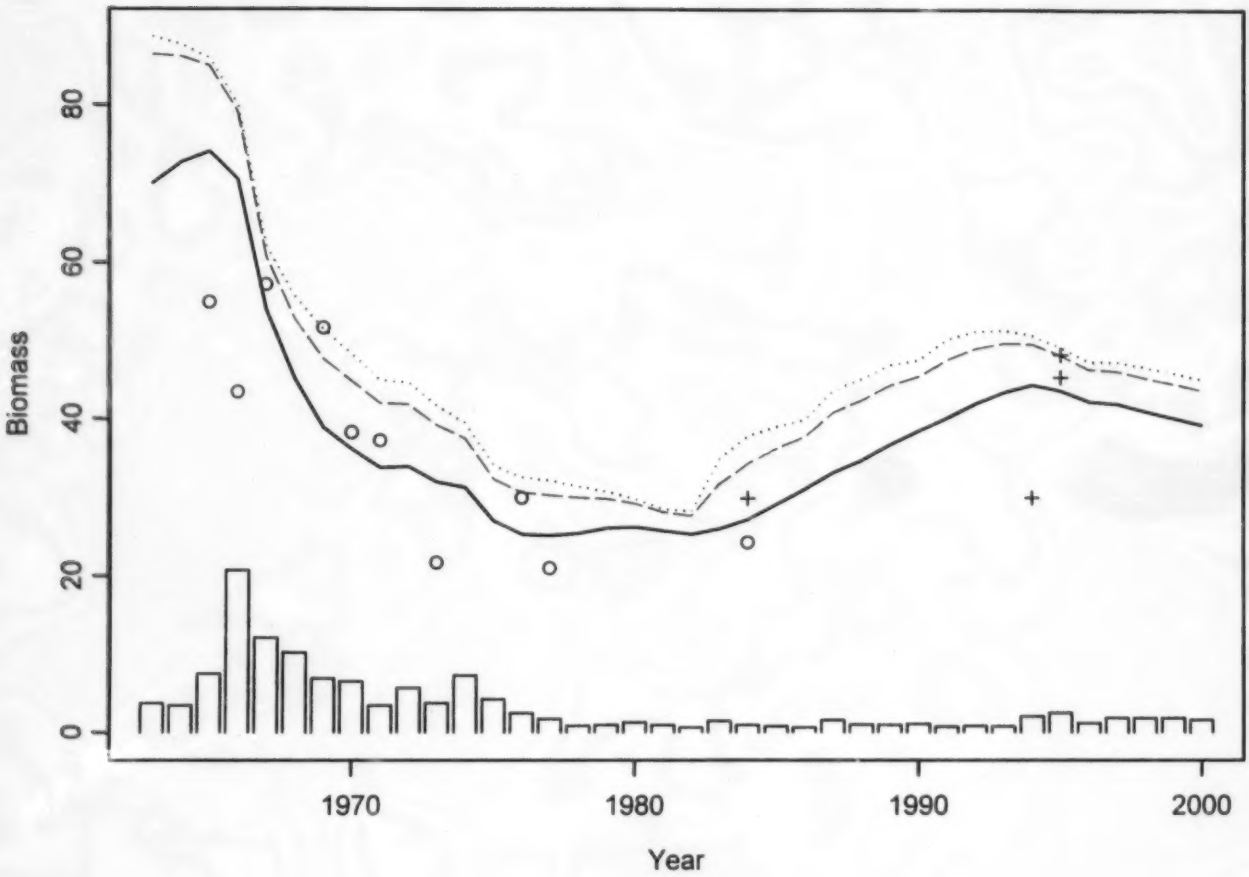

Figure 6. Annual Pacific ocean perch biomass estimates (10^3 t) in Goose Island Gully: biomass available to the fishery (solid line); mature biomass (dashed line); total biomass (dotted line). Circles and plus symbols indicate research and charter survey estimates, respectively, scaled to the available biomass. The bar plot represents annual catches.